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GLASS-BLOWING.

BROOKLYN, N. Y.

PLATE XX.

See page 976.

THE

PRACTICAL

DICTIONARY OF MECHANICS:

BEING

A DESCRIPTION OF TOOLS, INSTRUMENTS, MACHINES, PROCESSES, AND ENGINEERING; HISTORY OF INVENTIONS; GENERAL TECHNOLOGICAL VOCABULARY;

AND

DIGEST OF MECHANICAL APPLIANCES IN SCIENCE AND THE ARTS.

By EDWARD H. KNIGHT,

CIVIL AND MECHANICAL ENGINEER, ETC., U.S.

Illustrated

WITH UPWARDS OF FIVE THOUSAND ENGRAVINGS.

DIVISION III.

"Thus Time brings all things, one by one, to sight,
And Skill evolves them into perfect light."

LUCRETIUS, Book V.

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clock presented by Haroun al Raschid to Charlemagne, and which marked the hours by the sound of small balls falling, and also by the appearance of miniature horsemen through doors, was analogous in principle.

See under the following heads : —

Addendum.	Multiplying-gearing.
Angular gear.	Mutilated gear.
Annular gear.	Nest.
Back-gear.	Odontograph.
Bevel-gear.	Overhead-gear.
Cam-gear.	Pinion.
Chain-gear.	Pin-wheel.
Change-gear.	Pitch.
Cog-wheel.	Pitch-circle.
Cone-gear.	Pitch-wheel.
Conical gear.	Pivot-gearing.
Contrate-wheel.	Planet-wheel.
Crown-wheel.	Prime.
Differential gearing.	Rack.
Division-plate.	Rag-wheel.
Double-gear.	Ratchet.
Double gear-wheel.	Real-radius.
Eccentric gear.	Screw-gear.
Elliptical gear.	Scroll-gear.
Epicyclic gear.	Sector-gear.
Equatorial box.	Segment-gear.
Face.	Segment-rack.
Face-wheel.	Skew-gear.
Flank.	Skew bevel-gear.
Friction-gear.	Slosh-gear.
Gear-cutter.	Snail-gear.
Gear-cutting machine.	Speed-cones.
Gearing-chain.	Speed-multiplier.
Geometrical radius.	Spiral gear.
Hooke's gearing.	Sprocket-gear.
Hunting-cog.	Spur-wheel.
Interdental.	Star-wheel.
Intermittent gear.	Stepped-gear.
Internal gear.	Sunk-motions.
Irregular wheel.	Train.
Lantern-wheel.	Trundle.
Mangle-rack.	Variable gear.
Mangle-wheel.	V-gear.
Match-gear.	Waved gear.
Mesh ; mash.	Wiper.
Miter.	Worm-gear.
Multiple.	Worm-wheel.

Gear'ing-chain. An endless chain transmitting motion from one toothed wheel to another.

Gears. A name applied to harness, as the clothing (Anglo-Saxon, *geara*, clothing) of a horse. The word is usual in the West, and different kinds of harness are indicated by the names *single-gear*, *double-gear*, *lead-gear*, *hip-strap gear*, *Yankee-gear*, etc.

Gear-wheel. Any cog-wheel, whether crown, spur, internal-cogged, bevel, or lantern, is a gear-wheel. The essential feature is the possession of cogs, which act upon the cogs of another wheel in the train or series to impart or transmit motion. See GEARING.

Geat. (*Founding.*) The channel or spout through which molten metal descends into the mold. See GATE.

Geis'ler-tube. A sealed tube filled with rarefied gas, through which an electric spark is transmitted by means of platinum connections inserted at each extremity. On the passage of the spark, waves and bands of light make their appearance, which range in color and intensity according to the character of the gas with which the tube is filled. This apparatus is used with the induction-coil.

Gel'a-tine. An animal substance which assumes several forms, according to the material from which it is made and the mode of manufacture.

Common gelatine is made from clippings of hides, horns, hoofs ; and some is yielded by the feet, bones, tendons, and ligaments of animals.

In a jelly form it is called *size*.

The coarser qualities, dried in flakes, are *glue*.

When made from the membrane of fishes it is *isinglass*, the best of which is made in Russia from the air-bladders and sounds of sturgeon.

Gel'a-tine-pro'cess. The action which is at the bottom of nearly all the permanent photographic-printing processes is that of light on gelatine in presence of a bichromate. Dissolve gelatine in hot water, and add to the solution some bichromate of potash, and dry it ; the compound is sensitive to light in a way different from ordinary photographic paper. Exposure to light changes the color to a chestnut-brown, but, what is more important, it is no longer soluble in hot water. If a portion of the dried gelatine and bichromate be shielded from light, that portion will dissolve as readily as before, but the portion which has been acted on by light forms a tough, tawny substance which is unaffected by the hot water. The discovery of this action was made in various steps, the first change of color being announced by Mr. Mungo Ponton as early as 1839. This remarkable property was finally laid hold of by experimentalists, and two groups of processes have been founded upon it. In the first group, this action is brought into play in the production of every proof. That is to say, every picture is produced by the action of light on bichromated gelatine. In the second group, one picture is produced by the action of light on bichromated gelatine ; and this picture is made by various devices to serve as a printing matrix, from which any number of impressions may be struck off by mechanical means.

In the first group is included what is ordinarily called CARBON-PRINTING (which see). See also AUTOTYPE.

In the second group, the gelatine picture is used as a matrix for producing a printing-base, or is itself used as a printing-base, which is then in either case printed from by mechanical means. The first successful attempts in this direction resulted in the process which is known as photolithography. A print is produced by the action of light on paper coated with sensitized gelatine in the way first indicated. It is found that lithographic ink will adhere to those parts where light has acted. The gelatine print is accordingly inked with a lithographic transfer-ink, and the print thus produced is transferred to the surface of stone or zinc. But a lithographic stone does not do more than discriminate between black and white ; it will not recognize half-tones. The process is therefore only suitable for the production of work either in dots or lines. For this purpose it was used by Mr. Osborne in Australia, in Southampton, England, and now very extensively in this country. See PHOTOLITHOGRAPHY.

Poitevin's process, 1855, belongs to this group, and is typical of its kind. He coated the stone with bichromated albumen, and put it through the actinic processes *in situ*, then inked up on the stone.

Another process in the second group is PHOTOGALVANOGRAPHY (which see). See also PHOTOGLYPHIC ENGRAVING ; PHOTOZINCOGRAPH.

A third process is the *Woodbury*, in which a gelatine picture, having been obtained by light, is placed in contact with a sheet of soft metal, and submitted to heavy hydraulic pressure. Bearing in mind that the gelatine picture is a picture in relief

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and depression, the metallic counterpart obtained by pressure will be in reversed relief and depression. A mold will have been obtained, which it will only be necessary to fill with a solution of gelatine to obtain a duplicate, so to speak, of the gelatine picture from which the metallic mold was struck. The resulting picture will be one in relief and depression; but if, as in the case of carbon-printing, coloring matter is mixed with the solution of gelatine used to fill the metallic molds, it will also be in light and shade. A little solution of gelatine in hot water, containing suitable coloring matter, is poured into the metallic mold, a piece of paper is placed on the top, and a level lid pressed down on it, so as to squeeze out superfluous gelatine. In a few minutes the lid is opened and the paper removed, bringing with it the adhering gelatine, which, with the coloring matter, forms the picture. See WOODBURY PROCESS; NATURE-PRINTING; HELIOTYPE; ALBERTYPE, — so named from Herr Albert of Munich.

Gem. A precious stone, as a diamond, ruby, sapphire, emerald, topaz, opal, etc. Some of those in the following list are only semi-precious, and are not strictly gems. In a mechanical point of view, they have about equal interest. Some common and softer minerals are introduced for the sake of comparison.

Table of Hardness of Gems, etc.

Agate	12	Onyx	12
Amethyst	11	Opal	10
Calcareous spar	6	Quartz	10
Chalk	3	Ruby	16 – 17
Crysolite	10	Ruby spinelle	13
Carnelian	11	Sapphire	16 – 17
Crystal	11	Sardonyx	12
Diamond	18 – 20	Schorl	10
Emerald	12	Topaz	11 – 15
Fluor-spar	7	Tourmaline	10
Gypsum	5	Zeolite	8
Jasper	9 – 11		

Gem, Ar'ti-fi'cial. Factitious stones are made of very pure, fusible, highly transparent, and dense glass, usually called *paste* or *strass*. The composition is silica, potassa, and oxide of lead, with some other ingredients at times, and metallic oxides for coloring. (See GLASS-COLORING.) The beauty depends upon the clearness and the exact imitation of the natural gem, and also upon the care and skill in the cutting.

Gem-cut'ting. The surfaces of gems are cut into facets to increase their brilliancy. The greater the natural brilliancy the fewer facets are required to obtain a given brilliancy.

As a general rule, the back that is inclosed in the setting has double the depth of the face. The back is cut into facets or squares that exactly correspond in place with the position of the principal facets on the front of the stone; and the angles which the squares at the back make with the axis of the stone are required to be such that all the light reflected from their surfaces may fall within the central, flat surface, on the part of the stone called the *table*.

The parts of a cut gem are as follows: —

Front; the face or exposed portion.

Back; the rear portion.

Table; the central plane in the face.

Girdle; the extreme margin of a stone by which it is retained in the setting.

Top; the beveled portion between the *table* and the girdle.

Facet; a small face.

Cullet; a small central plane on the back.

See BRILLIANT.

Gem-cutting was not so well understood among the ancients as it is now, neither are the Oriental cutters equal to those of Amsterdam. The *Koh-i-noor* was recut after coming into the possession of the British queen. (See DIAMOND.) We read, however, of gem-cutting in Pliny and elsewhere.

"People bore into these red hyacinths (rubies) by means of the diamond." — AL KHÂZINÎ, 12th century.

The principal modes of cutting may be classed under three heads: —

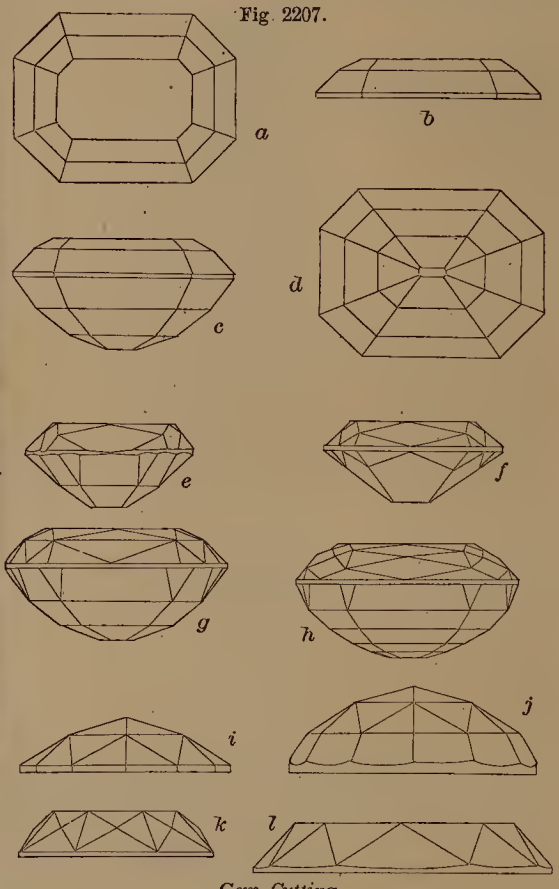
The *trap*, *brilliant*, and *rose cut*.

The *trap* (*a b*) *cut* consists of parallel planes nearly rectangularly arranged around the contour of the stone.

e d represents a thicker stone, trapped in two hights on the front and three on the back.

The *brilliant cut* consists of lozenge-shaped facets alternating with triangles, and is used for the fronts

Fig. 2207.



Gem-Cutting.

of most transparent stones that are sufficiently thick to allow of being cut into facets on both the front and the back.

There are several varieties of brilliant cuts, known as —

Half-brilliant *e*.

Full-brilliant *f*.

Split or trap brilliant *g*.

Double-brilliant or Lisbon cut *h*.

The *rose cut* (*i j*) consists of triangular facets arranged upon and around a central hexagon. This cut is employed upon such stones as are thin and large on the surface, as the rose cut is only applied on the surface and the back is left flat. The rose cut is considered to give the greatest luster that can be obtained from cutting the front only, as the surface is entirely covered with facets.

k is the X-cut; *l*, dental cut. Many other minor varieties might be cited.

Gem'el-hinge. (*Locksmithing.*) (Lat., *gemellus*, twin:) A hinge consisting of an eye or loop and a hook.

Gem'el-win'dow. (*Architecture.*) A window with two bays.

Gem-en-grav'ing. The art of engraving on gems. It is performed by small revolving wheels or points charged with diamond dust, emery, etc., according to the hardness of the gem. See SEAL-ENGRAVING.

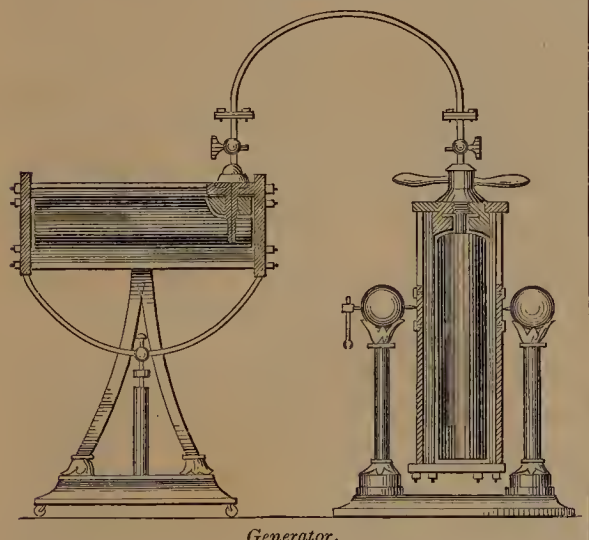
Gen'der. (*Music.*) A Javanese musical instrument introduced into England by Sir Stamford Raffles. It consists of a row of parallel metallic plates, supported horizontally by two strings passed through the respective nodal lines of the plates. The modern dulcimer with glass plates supported on tapes gives an idea of the method. Underneath each plate is an upright bamboo containing a column of air of such a length as to reciprocate the sound of the plate above. The resonance of the unisonant columns of air augments the sounds of the vibrating metallic plates.

Gen'er-at'ing-sur'face. The heating surface of a boiler, that on which heat is applied to generate steam.

Gen'er-a'tor. 1. (*Steam.*) A vessel in which steam is generated from water, for use in a steam-engine, a heating apparatus, etc. The term was first applied to the Perkins steam-boiler, in which water in small quantity was heated to great temperature. It is now specifically applied to a class of instantaneous generators. The name is now rapidly coming into use for all apparatus for generating steam, being held to be more correct than the usual term. See STEAM-BOILER.

2. (*Aërated Waters.*) An apparatus for generating carbonic-acid gas for charging soda-fountains, or

Fig. 2208.



Generator.

bottles with aërated water. One form is shown in the figure. The generator (shown on the right) is a lead-lined copper cylinder, supported on an axis, and containing the ingredients, which may be water, carbonate of lime, and sulphuric acid, which are commingled by the swaying or reversal of the chamber on its axis. The gas evolved passes to the receiver, where it is absorbed by the water, assisted by the swaying of the receiver on its axis. See AËRATOR, pp. 18 – 20.

3. A retort in which volatile hydrocarbons are distilled from solid or liquid matters. See GAS-MAKING; GAS-GENERATOR.

Ge'o-met'ric-al Lathe. An instrument belonging to the bank-note engraver. Like the CYCLOIDAL-ENGINE (which see), it is used for making complicated patterns of interlacing lines to form an additional guard against counterfeiting. It is adapted for more delicate and minute work than the cycloidal engine, and is the means by which the stars, rosettes, and ornamental tablets, escutcheons and borders, are produced around the denominating figures, etc., of bank-notes.

A graver whose normal motion is in a curve is made by the motion of the plate to form a waved line with any character of convolutions; this is crossed by one of somewhat varying character, and this by a third, and so on, forming an interlacing but regular pattern. If the plate move in a direct line, this pattern will have a general straight direction, but if the plate be moved in a circle, a circular pattern of interlacing lines will be the result. By cams and other devices the general trend of the figure may be made to fill a circle, ellipse, shield, or tablet of any form. Fair examples of the work may be seen on the face and back of the greenbacks of the United States, and it will be seen that the spaces and escutcheons consist of a series of concentric designs.

Machines of this character are very costly, and possessed by but few establishments; the Treasury of the United States and the American Bank-Note Company for instances. The difficulty of counterfeiting is much increased by the use of this mode of ornamentation.

Ge'o-met'ric-al Pen. An instrument for drawing geometric curves, in which the movements of a pen or pencil attached to a revolving arm of adjustable length are varied by changing the toothed wheels which give motion to the arm. — WEBSTER.

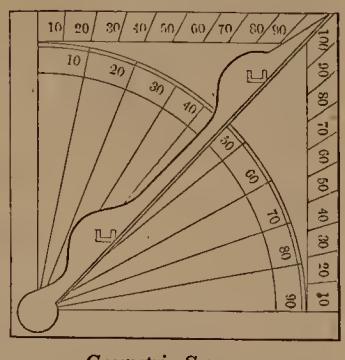
Ge'o-met'ric-al Ra'dius. (*Gearing.*) The radius of the pitch circle of a cog-wheel. The *real* radius is that touching the crests of the teeth.

Ge'o-met'ric-al Stairs. A stone stairs where the steps are secured into the wall at one end only, the other forming a continued string with an open newel.

Ge'o-met'ric Chuck. A chuck having a radial slider to which the work is attached, the said slider oscillating in a plane at right angles to the axis of motion, so as to produce curved lines in various patterns, as regulated by special devices. See GEOMETRIC LATHE; ROSE ENGINE-LATHE.

Ge'o-met'ric Square. An instrument for measuring distances and hights, and useful for its portability as well as for the facility, by the common rule of three, of solving most of the problems arising from its use. It is made of brass or wood, 12 or 18 inches square, and the quadrant is graduated in each direction. The two sides opposite to the axial point of the alidade are graduated to 100 equal parts, with major divisions of ten of said parts. The 100 point finishes at the angle obliquely opposite the center from which the arc is struck. One side represents the horizon, and the alidade with two sights is equal in length to the diagonal of the square. The alidade has divisions equal to those on the sides of the square.

Fig. 2209.



Geometric Square.

In measuring vertical hights, the distance is

measured from the station to the base, and by moving the alidade the angle subtended by the object is observed.

Ge-o-ram'a. A concave globe on the inside of which the countries, oceans, etc., of the earth are represented to the spectators, who stand on a framework inside.

The globe of Gottorp was 11 feet in diameter; that of Dr. Long was 18 feet in diameter. Mr. Wyld's, 1851–61, was 60 feet 4 inches in diameter. The concavity of each of these represented the terrestrial surface.

Wyld's globe was lighted by openings during the day and by gas at night. See GLOBE.

Ge'o-stat'ic Arch. (*Architecture.*) A linear arch of a figure suited to sustain a pressure similar to that of the earth, which consists, in a given vertical plane, of a pair of conjugate pressures, one vertical and proportional to the depth below a given plane, horizontal or sloping; and the other parallel to the horizontal or sloping plane, and bearing to the vertical pressure a certain constant ratio depending on the nature of the material, etc. — RANKINE.

Ge-o-ther-mom'e-ter. An instrument for measuring the earth's heat at different depths, as in mines and wells. The temperature rises about 1° Fah. for every 70 or 80 feet of descent.

Ger'man-bit. A wood-boring tool adapted to be used in a brace. It has a long elliptical pod and a screw-point. See BIT.

Ger'man-chest. (*Metallurgy.*) (*Caisse a tombeau*, coffin.) An apparatus resembling a *trunk* in some respects. It is a long box into which the *slimes* are carried gradually by a stream of water. The heavier portions settle near the head of the box, and the lighter towards the lower end, where the water escapes at holes from which the pegs are withdrawn; a lower peg being replaced and the discharge-opening being made a little higher up as the box gradually fills.

Ger'man-sil'ver. A white alloy for table ware, consisting of nickel, copper, and zinc in various proportions: —

	Nickel.	Zinc.	Copper.	Cadmium.	Iron.	Tin.	Lead.	Antimony.
Brande	1	1	2					
Brande	8	3.5	8					
Parisian	20	5.5	70	4.5				
Packfong (Chinese)	31.6	25.4	40		2.6			
Parke's (Eng. patent, 1844)	45.5	21	91		45.5			
Cutler's (Eng. patent, 1838)	5	5	16		3			
Toucas's (Eng. patent, 1856)	4	1	5			1	1	1

Another authority gives: —

	Nickel.	Zinc.	Copper.
Common albata	3.5	16	20
Best albata	5.5	9	20

Another: —

	Nickel.	Zinc.	Copper.	
German silver (finest quality)	1	2	1	
German silver (for rolling)	25	60	20	Lead.
German silver (for casting)	20	60	20	20
German silver (original formula)	32	40	25	Iron. 3

It is said to have been originally obtained from a metallic ore found at Henneburg, whose analysis is nearly the same as the last formula given above.

Ger'man-steel. A metal made of charcoal-iron obtained from bog-iron or the sparry carbonate.

Ger'man-tu-ta'nia. An alloy of copper, 1; tin, 48; antimony, 4.

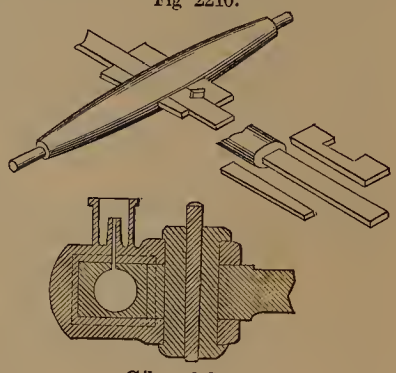
Ger'man White-cop'per. An alloy of copper, 88; nickel, 8.75; with traces of silex, aluminium, antimony, and arsenic.

Get-in. (*Printing.*) An order to condense matter so that it shall not extend beyond the end of a line. *Run in.*

Gi'ant-pow'der. A form of *dynamite*, consisting of infusorial earth saturated with nitro-glycerine. The silicious earth consists of diamtoms and frustules, and the result is a brown powder, something like fine sawdust.

Gib. A piece of metal or wood whose duty it is to hold another in place, as in the case of a sled-tongue in its roller, or a strap-head on a connecting-rod. See KEY.

Fig 2210.



Gib and Cotter.

It is usually tightened by a key or cotter, as in the annexed illustration, which shows a very common mode of securing the tongue in the roller of a sled. The notched *gib* is placed in the mortise of the *roller*, the *heel of the tongue* inserted, and a wedge-shaped *cotter* is driven in to tighten them all in place. Pins prevent the endwise withdrawal of the *tongue* or *cotter*.

Gib. 1. *Gib and key.* The fixed wedge and the driving wedge for tightening the strap which holds the brasses at the end of a connecting-rod in steam machinery. See lower illustration in Fig. 2210.

2. The projecting arm of a crane. *Gibbet, jib.*

Gib'bet. The post and arm of a crane, reaching over for the suspension of the load therefrom.

Gif'fard In-ject'or. A steam-jet which acts upon a body of water by which it is condensed, and to which it communicates its velocity, driving it through the feed-water pipe into the boiler. See INJECTOR.

Gig. 1. (*Vehicle.*) A light, two-wheeled vehicle, drawn by one horse.

2. (*Fabric.*) A rotary cylinder covered with wire teeth for *teaseling* cloth.

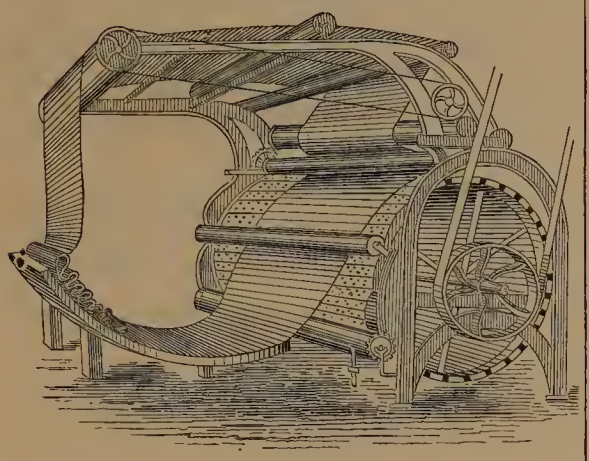
3. (*Nautical.*) A clinker-built boat, from 20 to 28 feet long, and rowed with 4, 6, or 8 alternate oars. It is reserved for the commanding officer. Usually nearly the size of the cutter, but of longer and slenderer build.

4. A fish-spear.

Gig'ging-ma-chine'. A machine for dressing woolen cloth by subjecting it to the action of teasels, whose fine hooks draw the loose fibers to the surface. A *napping-machine.*

The teasel is a kind of thistle (*Dipsacus fullonum*) cultivated for the purpose. The awns or bracts of the prickly head are furnished at the ends with little hooks, which are sufficiently strong to overcome slight impediments in drawing the loose ends of the filaments of wool to the surface. If the hooks of the teasel become engaged with knots which they cannot disentangle, they break, and it is this property which renders them so peculiarly suitable for this purpose. Artificial teasels, such as wire cards, have hitherto failed to answer the purpose as fully,

Fig. 2211.



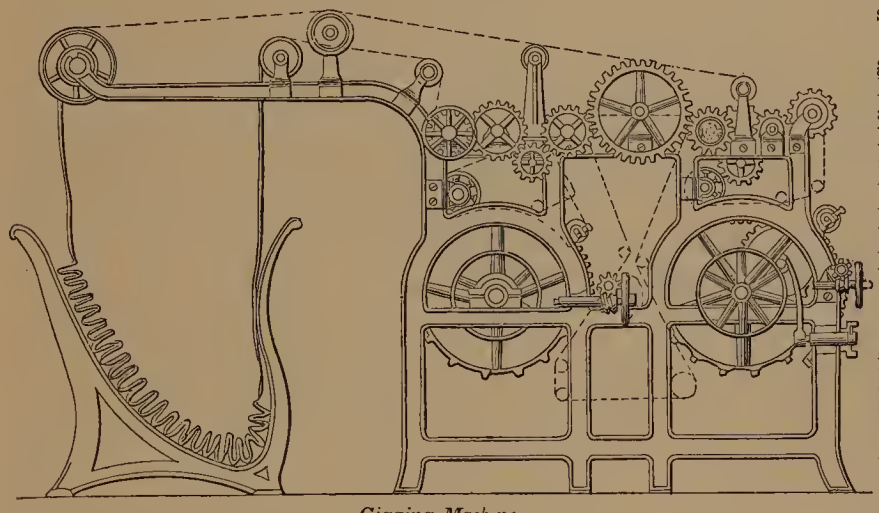
Gigging-Machine.

on account of their unyielding nature when they become engaged with a knot.

From 2,000 to 3,000 teasel-heads are arranged in frames attached to a hollow drum or cylinder, and the cloth, guided by rollers, is drawn in a direction contrary to that of the cylinder, the latter revolving somewhat rapidly and the cloth passing more slowly.

In the illustration, the ends of the cloth are sewed together so as to make it a continuous band which

Fig. 2212.

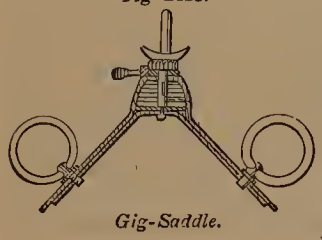


Gigging-Machine.

pssses round again and again. See TEASELING-MACHINE.

In Fig. 2212 the cloth is teaseled in opposite directions on the same side without removal from the machine, and may be presented twice to each teaseling cylinder. It does not pass under the cylinders so as to catch the falling dirt, etc., and its napped surface is uppermost for inspection at all times.

Fig. 2213.



Gig-Saddle.

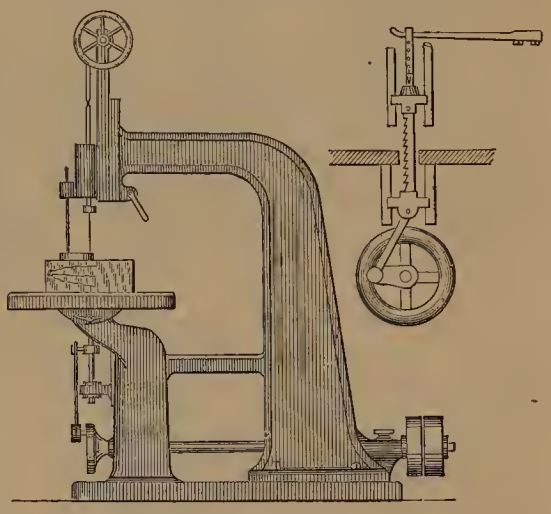
Gig-ma-chine'. See GIGGING-MACHINE.

Gig-mill. A machine in which woolen cloth is napped or teaseled. A *gigging-machine.*

Gig-sad'dle. (*Saddlery.*) A small saddle used with carriage-harness, and carrying the *terrets* for the *driving-reins* and the *check-hook* for the *bearing-rein.*

Gig-saw. A thin saw to which a rapid vertical reciprocation is imparted, and which is adapted for

Fig. 2214.



Gig-Saws.

sawing scrolls, frets, etc. The motion is imparted by the crank and pitman, and the spring above *gigs back* the saw, keeping it strained on its upward stroke.

Scroll-saws are usually gig-saws or band-saws. In Fig. 2215, the saw-guides and operating mechanism have rotary adjustment around the point where the saw passes through the table so as to saw to a bevel. The motion of the hand-crank operates the worm *E*, which moves the segment *D* in the curved guides *C b*. The saw *H* is strained between the ends of levers *I I*, which are pivoted to the segment *D*. Thus the angle of the saw is capable of adjustment in a range of 90°; that is, 45° on each side of the perpendicular, while the other adjustments are the circular and vertical of the table beneath.

Gig-tree. The frame of a gig or harness saddle.

Gild'ing. The process of overlaying with gold.

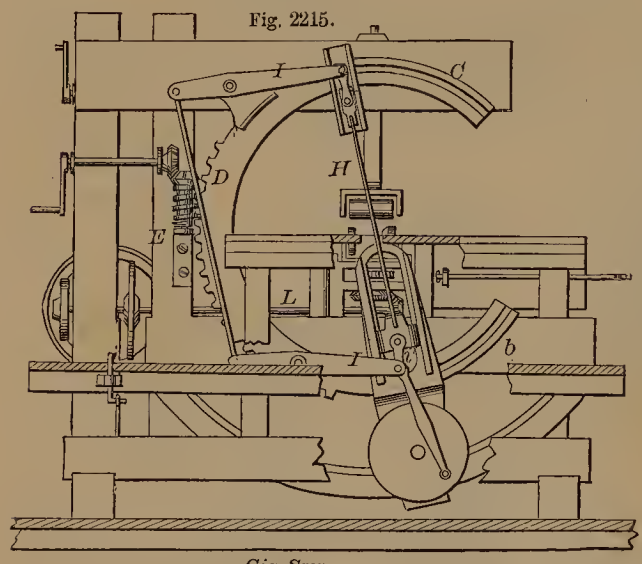
Substances overlaid with fine gold-leaf are found in connection with the earliest Egyptian monuments, even as early as Osirtasen, 1706 B. C. In the time of Thothmes III., the era of the exodus, they had various modes of applying; in leaf, inlaying, or by beating it into other metals. Specimens may be seen in Dr. Abbott's collection, New York. We read that the wood of the ark was overlaid with gold, 1490 B. C.

It was lavishly practiced in ancient Rome; parts of the Capitol were thus ornamented, a single ounce only making 450 leaves, each four inches square.

Gilding is performed: —

1. By laying on gold-leaf.

Fig. 2215.



Gig-Saw.

2. By applying gold in amalgam, the mercury being subsequently evaporated.

3. By electro-plating.

4. By a sheet of metal soldered to the cheaper foundation metal.

5. By enameling.

A German plan cited in the "Philosophical Transactions for 1698" is described: —

Steep linen rags in a solution of gold, burn them; with a piece of cloth saturated in salt-water rub the ashes upon the silver. It is not durable.

The modes and purposes are various: —

Burnished gilding is destemper gilding polished by burnisher, and is used especially in picture-frames.

Chemical gilding is produced by galvanic action in the bath, or by affinity. See ELECTRO-PLATING; WASH-GILDING.

Cold gilding consists in rubbing the annealed metal with gilding-powder by means of a piece of cork dipped in salt-water. Polish with steel-burnisher.

Destemper gilding is applied to wood, plaster, or marble. Coat with size, followed by successive coats of finely powdered whiting, and face by rubbing with sand-paper between each coat. Coat with gold size, lay on the leaf, and polish with an agate or dog's tooth.

Electro-gilding. See ELECTRO-PLATING.

Friction gilding. See above, — *cold gilding.*

German gilding; a name for ELECTRO-PLATING (which see).

Immersion gilding; dipping the metallic article into a solution of pyrophosphate of soda in which terchloride of gold has been dissolved.

Or in a boiling-hot gilding-liquor of nitro-muriate of gold, water, and bicarbonate of potassa. (Elkington's patent.)

Or in a solution of gallic acid in water, ether, or alcohol, to which a solution of gold has been previously added. (Tabbot's patent.)

Japanners' gilding. Cover the surface with oil-size thinned with spirits of turpentine, and dab in gold in powder with a puff of wash-leather.

Leaf gilding; coat the paper or vellum with gum-water or glaire, lay on the leaf-gold and polish with an agate.

Mechanical gilding; any process in which the gold is made to adhere by glue, in contradistinction to chemical processes.

Mercurial gilding, by amalgam. See WASH-GILDING.

Oil gilding; coat with size; then repeatedly with calcined white lead or massicot ground in linseed-oil and turpentine; shave smooth the dried surface after each application; coat with gold size, then with the leaf; varnish; heat over a chafing-dish; varnish.

Varnish gilding, for carriages, etc. The same as above, except that the surface is varnished before receiving the gold, repeatedly varnished afterwards, and polished with tripoli and water.

Wash gilding; apply amalgam of gold and volatilize the mercury by heat.

Water gilding, same as *wash gilding.*

To state more in full: —

1. Gilding by gold-leaf is divided into, —

a. Burnish gilding.

b. Oil gilding.

a. In *burnish gilding,* the surface of the looking-glass or picture-frame stuff is prepared by *priming* of *white stuff,* laid on with a brush and followed by several thicknesses of the same material (hot size and whiting), but of a thicker consistence. This surface is smoothed and polished, then covered with several coats of a *size* made of pipe-clay, red chalk, black lead, suet, and bullock's blood, reduced by a solution of gelatine to the required thickness, to be laid on by a brush.

In gilding, the surface is wetted by a camel's-hair brush, the leaf is raised from the *cushion* by a tool called a *tip,* and laid upon the adhesive surface.

It is then burnished by a flint or agate burnisher, except in those parts where the gold is to have a *dead* or *frosted* appearance, called *matt,* and which are subsequently covered with size.

The tools of a gilder are a *cushion, knife,* and *tip.*

The *cushion* is flat, made of several thicknesses of cloth, and covered with leather. It has a marginal wall of parchment at one end and half-way along two sides.

The *knife* is pointed, straight-edged, and is not very sharp.

The *tip* is a layer of camel's hairs, whose but-ends are held between two cards which are glued together, forming a very light and elastic brush.

The gold-leaf is supplied by the gold-beater in books of 25 leaves, each measuring $3\frac{1}{8} \times 3$ inches.

A leaf being transferred from the book to the cushion is cut up by the knife into strips and pieces of the proper size and shape to lay upon the work, to which they are transferred by the *tip.* This tool being laid gently upon the leaf, the latter adheres slightly to the hairs, and is thereby raised and deposited in its place on the surface to be gilded.

b. Oil gilding differs from burnish gilding in the preparation of the surface, which is by coatings of *white stuff, clear cole* (a priming prepared with size instead of oil), and oil gold-size. The latter is a mixture of boiled linseed-oil and ochre, laid on by a brush.

The gold-leaf is laid on as in the former process, and is covered with a clear size.

Where parts are to be burnished, they are left for treatment by the *burnish* process just described.

2. An amalgam paste (see AMALGAM) is applied with a brush to metallic articles, which are prepared for its reception by aqua-fortis. Heat, carefully applied, drives off the quicksilver; the surface may be improved by burnishing. The name *water gilding* is also applied to this process. See WATER-GILDING.

3. A bath consisting of a chemical solution of

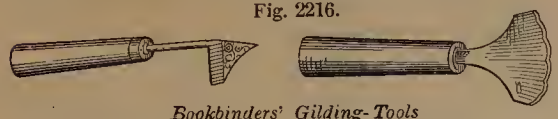
gold is prepared, and the object to be gilded is rendered electro-negative, and suspended in the liquid. A galvanic current being passed through the article suspended in the liquid, the gold becomes deposited upon it. Non-metallic articles may receive a coat of plumbago, to induce deposition thereon. A plate of gold is suspended in the liquid to feed the latter as it becomes impoverished. See ELECTRO-PLATING.

4. The form of gilding by soldering on a plate of the metal is seldom applied with gold, but is common with silver. A cheaper metal forms a basis or foundation to which is soldered a plate of gold. The two are then rolled down together, becoming gradually attenuated until they reach the required thickness, when they are worked together into the shape or object required.

Porcelain or glass is gilded by a magma of gold, quicksilver, gum-water, and borax. It is laid on with a hair-pencil, being thinned with turpentine and oil, like paint. It is black when used, but its natural tint is restored by burning in the enamel-kiln. The borax acts as a flux to unite the gold to the ceramic or vitric material. It comes dead-colored from the kiln, but is brightened by the burnisher.

1. (*Bookbinding.*) In gilding, the book is placed in the press between two boards, and the edges being cov-

Fig. 2216.



Bookbinders' Gilding-Tools

ered with *glaire* (albumen), a layer of gold-leaf is laid on and rubbed with an agate burnisher, fixing it to each leaf and at the same time giving it a polish.

In tooling, the portion of the cover is covered with glaire, the leaf laid thereon, and a heated tool carrying the desired ornament is pressed thereon. The tool may be a hand-stamp, as in the figure, or a roller or fillet having a periphery on which the pattern is repeated all round. The other appliances of the gilder are the cushion, knife, tip, etc.

Or: the surface is dusted with gum-mastic; the heated tool laid on the gold, which it catches up and transfers to the cover; pressure causes it to adhere.

Brass buttons are gilded by throwing them into a pan with a little amalgam of gold, and as much diluted aqua-fortis as will wet them all over; stir till they appear silvery, then wash, dry, and heat to volatilize the mercury.

Glass and porcelain are gilded by blending powdered gold with gum-water and borax to the biscuit, heating in a muffle, and polishing with a burnisher.

2. (*Photography.*) The treatment of the finished daguerreotype-plate with a salt of gold, generally sal d'or, — the hyposulphite of gold and soda, — which determines the deposition of finely divided gold upon the vaporous mercurial deposit of which the picture consists. By this means permanence is imparted to the picture.

Gild'ing-size. A viscid composition laid upon an object to hold a surface of gold-leaf. The bookbinder uses *glaire*, white of egg. The *oil-gilder* uses a mixture of linseed-oil and ochre.

Gill. 1. A *hackle*. A series of points which divide the ribbons of flax fiber into finer parallel filaments ready for drawing and spinning. A *porcupine*.

2. A timber vehicle consisting of a pair of wheels and a frame.

3. A measure of a fourth of a pint.

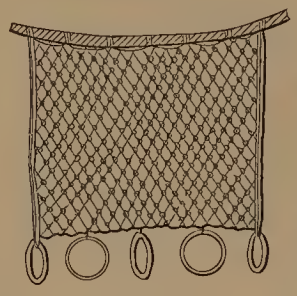
Gill-frame; Gill-head. A machine in which *stricks* of flax are drawn out into *slivers;* doubled and combined with other slivers, and redrawn until they assume the character of *rovings*, and are ready for the spinning operation. A *spreader*.

The name *gill-frame* (Fr. *aiguille*, needle) is derived from a number of vertical needles forming a comb, through which the *line* passes to the drawing-roller; the *gill* is attached to a *fuller-bar*, which rises and falls at intervals, and alternately detains and releases the *line*, which, by a series of operations, is converted from a *strick* to a *sliver* and then to a *roving*. See SPREADER.

Gill'ing-ma-chine'. A draw-head machine for flax. A GILL-FRAME (which see).

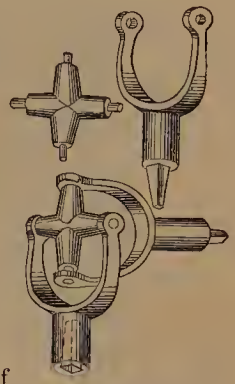
Gill-net. One suspended in a stream, having meshes which allow the heads of the fish to pass, and which catch in the gills to prevent the fish from detaching itself.

Fig. 2217.



Gill-Net.

Fig. 2218.



Gimbal-Joint.

Gim'bal-joint. A form of *universal* joint. (From *gemellus*, Latin, twin.) A two-part joint having articulations on axes at right angles to each other. Invented by Hooke. It is used as a shaft-coupling in the tumbling-rods of horse-powers, in drilling and sheep-shearing machines and elsewhere.

Gim'bal-ring. A single gimbal by which the cock-eye of the upper mill-stone is supported on the spindle to permit vibration. A *rynd*.

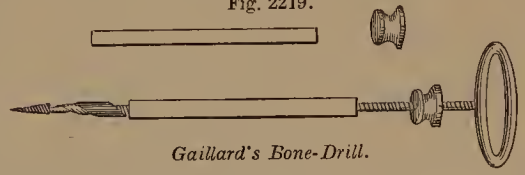
Gim'let. A small boring-tool. It has a leading screw, a grooved staff, and a cross handle.

Its invention is ascribed by Pliny to Dædalus, an artificer of Athens, about 1240. He considered it a point of honor to give an author in each case. In England it was formerly called a *wimble*.

The Grecian gimlet (*teretrion*) is frequently mentioned.

Gaillard's instrument for the insertion of steel pins in the treatment of fractures has four pieces. the handle, screw, sheath, and nut. The silver sheath is passed down to the bone, which is then bored by

Fig. 2219.



Gaillard's Bone-Drill.

the gimlet. The nut is then screwed down to draw the parts into apposition, and is left until bony adhesion takes place.

Gim'mal. A pair, or series, of interlocked rings. A *gimbal* (from *gemellus*, twin).

Gimp. (*Fabric.*) Silk twist interlaced with wire or a coarse cord. Used for trimming.

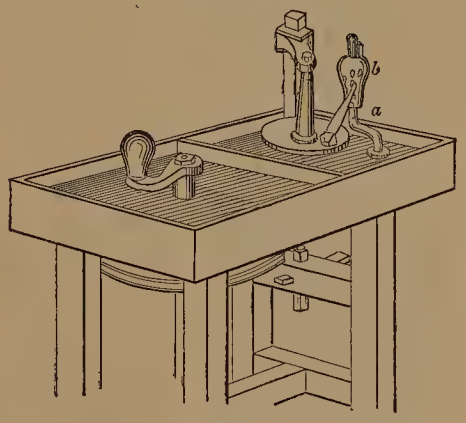
"My wife's black silk gown is now laced all over

with black gimp lace, as the fashion is, in which she is very pretty." — PEPYS's *Diary*, 1661.

Gim-peg. A rest for the arm of a lapidary, consisting of a rod of iron bent into a cranked form *a*, and fitted with a flange that bears upon the surface of the bench.

It also serves as a holder for a block *b*, which is slipped thereon, and which serves as a guide for the vertical angle in cutting facets. The end of the stick is placed in one of the series of holes in the block, according to the angle required for the facet.

Fig. 2220



Gim-Peg.

The tang of the gim-peg is secured beneath the bench, and the block is secured by a wedge to the gim-peg.

Gimp-ma-chine'. A narrow-ware loom having devices at the edge of the warp to catch the woof and form loops or patterns, the gimp cords of various sizes being carried by independent shuttles or needles.

Gimp-nail. A small forged nail with a rounded head, used by upholsterers.

Gin. 1. A portable hoisting-machine *a* whose frame is a tripod, one leg being movable so as to vary its angle of elevation, and thus determine the hight of the apex; the other two legs preserve their relative distance, and form standards for the drum, around which the rope is wound by power applied to the hand-spikes. For heavy weights a fall and tackle is used; and for hoisting a bucket from a well or mine, simply a couple of pulleys to change the direction of motion of the rope. One pulley is suspended from the apex, and the other attached between the two permanent legs, so as to change the rope to a horizontal position, for the attachment of draft horse.

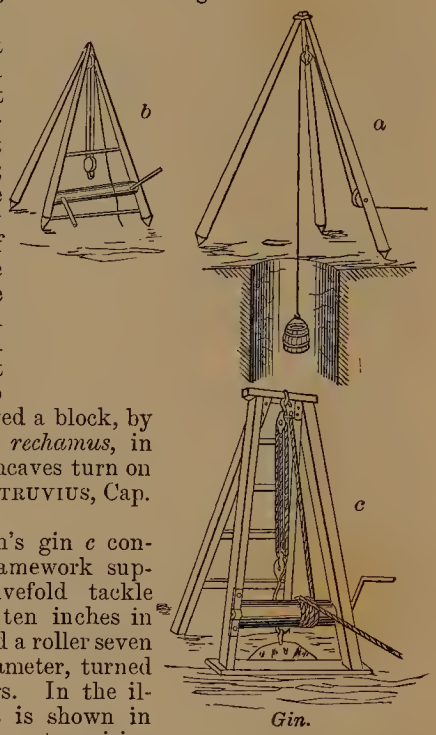
The gin *b* with fall and tackle is used for loading heavy objects, mounting ordnance, moving heavy castings in foundries. It is the most convenient form of portable hoisting-machine in places where traveling cranes and elevators cannot be had. The *shears* has two legs and the *derrick* one; the latter two require guys. See CRANE; DERRICK; WHIN; CAPSTAN; WINDLASS; WINCH; ELEVATOR.

In the United States military service gins are divided into three classes, — *field*, *garrison*, and *casemate*. Each is comprised of the same pieces, differing only in size and minor details of construction. The parts are the *legs*, the *prypole*, which is in fact the third leg, the *braces*, the *clevis*, and the *block* and *fall*.

A similar contrivance to the gin is mentioned by Vitruvius (about 40 B. C.): —

"Three pieces of timber are prepared, suitable to the weight to be raised, connected at the top by a pin, but spreading extensively at the feet; these are raised by means of ropes made fast to the top, and when raised are kept steady; to the top is fixed a block, by some called *rechamus*, in which two sheaves turn on axles." — VITRUVIUS, Cap. II., lib. 10.

Fig. 2221.



Gin.

Richardson's gin *c* consists of a framework supporting a fivefold tackle with blocks ten inches in diameter, and a roller seven inches in diameter, turned by iron levers. In the illustration, it is shown in its application to raising surface stone for removal out of the way of the plow.

2. A pump operated by windmill.

3. A coal-hoisting machine. See WHIN.

4. A snare for birds or animals.

5. A spirit distilled from grain and flavored with juniper berries.

6. A machine for separating cotton-fiber from the seeds.

Eli Whitney's cotton-gin, invented in 1793, revolutionized the culture and manufacture of the fiber by providing a mode of putting it into merchantable order at a reasonable price.

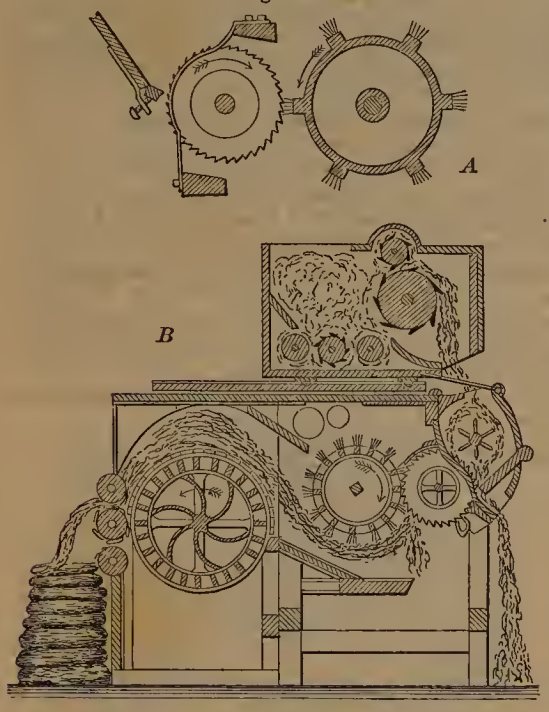
When done by hand, a man can clean but one pound per day. The *roller-gin* of India and China cleans from 40 to 65 pounds in a day. It has two rollers, which catch the fiber between them and carry it away, while the seed is detained by a comb.

The combing instrument used in the Spanish colonies for removing the seed from the cotton-fiber is called *almarraes*. The syllable *al* indicates the Saracenic origin of the tool and its uses.

In Whitney's saw-gin (*A*) the cotton is placed in a long and narrow hopper, one side of which is formed by a grating of strong parallel wires $\frac{1}{8}$ inch apart. Close to the hopper is a roller with circular saws $1\frac{1}{2}$ inches apart. These, as they revolve, pass within the grating to a certain depth, and seize the fibers of cotton, dragging them between the wires which detain the seeds. The cotton is swept from the saws by a revolving cylindrical brush.

In the lower view (*B*) is a more modern form of the same invention. The feeding-chamber is mounted above the gin, serving the double purpose of picking open and thoroughly separating all lumps and matted seed-cotton, and feeding it steadily and uniformly the whole width of the gin in small pellets or masses to the chamber below, in which is a roll-supporter, which presents the cotton regularly to the saws, and is itself driven by the action of the saws upon the under side of the roll. The brush cylinder removes the lint from the saws and delivers it into a chamber, which has for its bottom a revolving gauze cylinder, through which the air escapes while

Fig. 2222

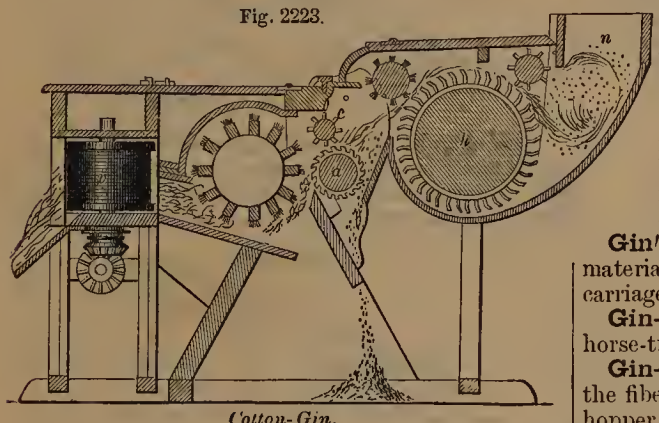


Cotton-Gin.

the lint is arrested and gathers upon the surface of the cylinder in a continuous bat, and is discharged by doffing-rollers ready for the press.

Fig. 2223 shows a form in which the cotton is taken by a toothed feeding-cylinder *h* from the hopper *n*, a stripper keeping superfluous cotton in the hopper; a brush-cylinder delivers the cotton from the feeding-cylinder *h* to the ginning-cylinder *a*. *c* is the brush-cylinder, and *v* one of a pair of wire-cloth covered condensing rolls, which press the cotton into a sliver and at the same time conduct away the dust and motes.

Fig. 2223.



Cotton-Gin.

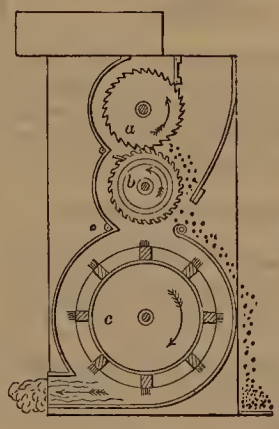
Other gins operate by means of rollers and knives and pinching devices which grasp the lint and tear it from the seeds, as in the roller-gin of India, already mentioned. In one case, as the combs alternately move up and down, they act upon the cotton, which is drawn in by the continuously revolving rolls, and comb back the seeds by working against the upper and lower edges of the bar.

In another, the fiber is grasped by positive devices close by the seed, and is so held while another part pushes the seed away from the fiber. The holders work intermittingly, or two sets alternately, one set holding the fiber or drawing it away, while the other set pushes the seeds away.

Another has a roller-knife acting in combination with a gin-roller, and *doctor* or pressing-knife, the roller-knife having fixed thereon a series of circular plates or disks, the edges of which come nearly in contact with the edge of the doctor or pressing-knife, and also with the surface of the gin-roller, in such a manner as to cause the seed and refuse to be beaten off, and at the same time to cause the fibers and seeds to be moved to and fro along the edge of the doctor.

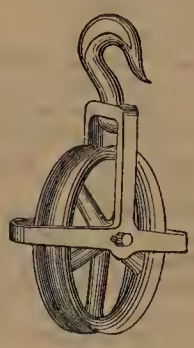
Calvert's toothed-roller gin has a guard-toothed roller *b*, which acts in conjunction with a guard-roller *a* to remove the lint from the hopper and keep back the seeds. The brush-roller *c* removes the lint from the roller *b* and conducts it to the exit.

Fig. 2224.



Calvert's Gin.

Fig 2225.



Gin-Block.

Gin-block. A tackle-block with a hook to swing from the gib of a crane or from the sheer of a gin.

Gin'gal. An East Indian breech-loading fire-arm carrying a ball of from four to eight ounces. See JINGAL.

Ging'ham. (*Fabric.*) A linen or cotton goods, colored in the thread.

Ging'ing. The lining of a shaft with bricks or masonry.

Gin'gly-mus. An elbow-joint which permits no other motion than in one plane, having no rolling articulation. Such a joint is the ordinary two-leaved hinge which moves on a pintle; such are also most *toggle* joints.

Gin'ny-car'riage. A railway car for conveying materials; probably English provincial for engine-carriage.

Gin-race. (*Mining.*) A miner's term for the horse-track of a whin or hoisting apparatus.

Gin-saw. One used in a cotton-gin for drawing the fibers through the grid, leaving the seed in the hopper. See GIN.

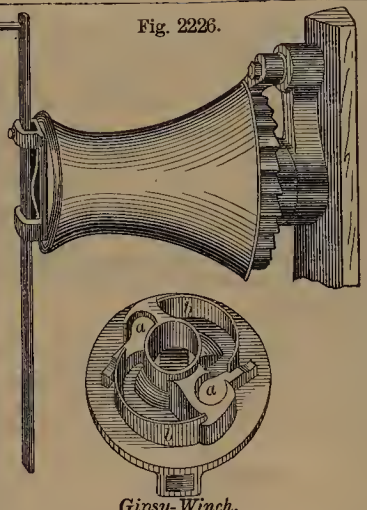
Gin-wheel. 1. A wheel in a cotton-gin. It may mean a wheel with curved pointed teeth or claws, which act as the teeth of the usual saws in drawing the fiber through the grid; or the brush-wheel, which cleans the lint from the said wheel or saw. See GIN.

2. The wheel or drum of a whin.

Gip'sy-winch. A small winch having a drum, ratchet, and pawl, and attachable to a post. The handle of the winch is attached by stirrups to a cap revolving on the axis. This cap is provided with a pair of pawls *a*, which, by means of springs *b*, are forced against ratchet teeth in the interior of the small end of the barrel. By this means two motions can be applied to the winch, the ordinary rotary method

of working the handle, and a reciprocating motion in which the handle is worked up and down like a pump-handle. In the ordinary rotary motion the ratchet movement of the cap is not utilized; but, when the maximum power of the apparatus is required, the pumping motion is adopted. The handle is extensible according to the power required, and about ten times the usual power may be obtained by the reciprocating motion, owing to the leverage obtained and the favorable position for the workman to throw his weight upon the handle, as in working a windlass. See also BRACKET-CRAB.

Fig. 2226.



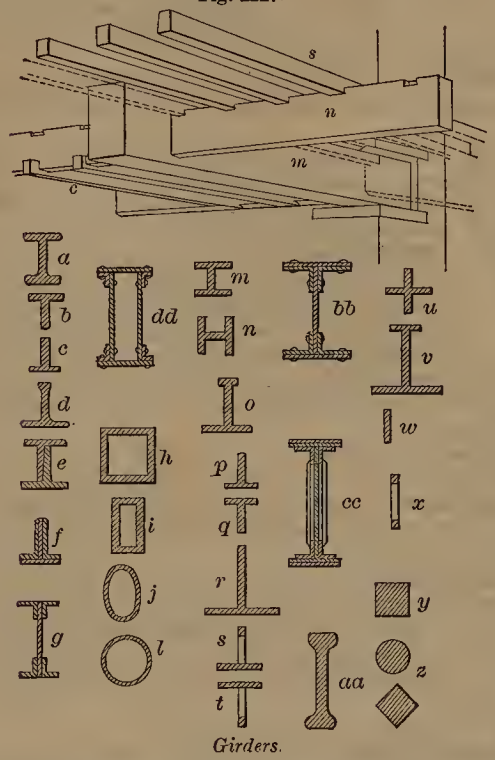
Gipsy-Winch.

Gir'an-dole. A branching candle-holder or chandelier. A *gasalier*.

Gird'er. A principal beam of a floor, spanning the distance from wall to wall, and affording a place of attachment for the *binders*, to which the floor and ceiling joists are connected.

In roofs of a less compound structure, the girder or summer-beam, sometimes trussed, spans the building longitudinally, and the joists proceed from it to the walls on each side. See FLOOR.

Fig. 2227.



Girders.

Girders are often compound, the timbers being scarfed together and stayed by truss-work or fished at the junction.

Smeaton bent the girders upward and trussed them in that position.

In double-framed floors, the *binding-joists* *n*, instead of resting on the walls, are supported by large timbers *m*, called *girders*. The *bridging-joists* *s* rest on the binding-joists *n*, and the *ceiling-joists* *c* are secured beneath the girder *m*.

a to *l* are forms of wrought-iron girders.

m to *z* are forms of cast-iron girders.

Plate-iron girders are made of several forms.

The *I-girder* *a a* is rolled in one piece.

The *compound I-girder* *b b* has flat top and bottom plates secured by *angle-irons* to the *web*.

Another form of *compound-beam* *c e* has upper and lower members built of several layers of plates riveted to each other, and to a pair of angle-irons whose other arms are riveted to the web, which is strengthened by vertical T-irons.

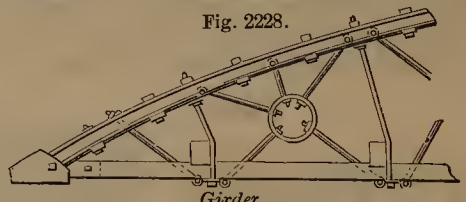
The British rule for wooden floor girders is as follows: —

Length of Bearing. Feet.	Depth. Inches.	Width. Inches.
10	9	7
12	10	8
14	11	9
16	12	10
18	12	11
20	13	11
22	14	12
24	15	12
26	16	12
28	16	13
30	16	14

The *box-girder* or *box-beam* *d d* has a double vertical web. It is stated by Rankine to have been long employed in the platforms of blast-furnaces, and to have been first used in railway bridges by Thomson, on the Pollok and Gowan Railway, in 1832.

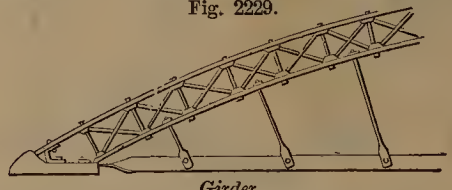
Figs. 2228 and 2229 are forms of arched girders for bridges. The former has for an arc a flanged iron beam and tension trussing in panels. The arch of the latter is formed of upper and lower concentric iron arcs connected by diagonal and radial braces. The chord is connected to the arch by radial rods.

Fig. 2228.



Girder.

Fig. 2229.



Girder.

The ends of the arch and chord are secured in the metallic shoe. See also LATTICE-GIRDER; HALF-LATTICE GIRDER; BOWSTRING GIRDER; LATTICE; TRUSS; ARCHED BEAM, etc.

The Girard Avenue Bridge over the Schuylkill, at Philadelphia, has five spans of wrought-iron lattice girders, and is illustrated under IRON BRIDGE. Under the same title are also shown a number of cast-iron and wrought-iron bridges.

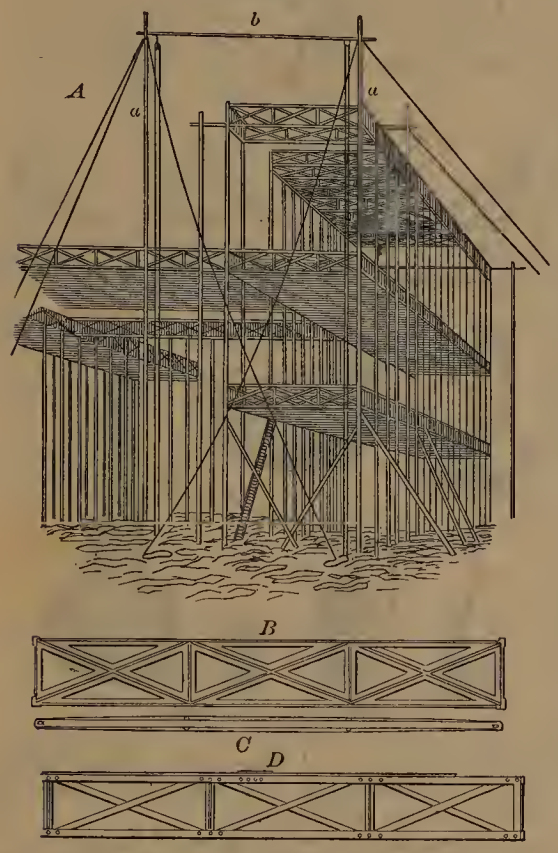
See also PIVOT-BRIDGE, where are girder-trusses resting at midlength on piers. See also STEEL TUBULAR-BRIDGE; TUBULAR-BRIDGE.

See also IRON, ANGLE, where a large number of forms of angle-iron are shown.

Fig. 2230 *A* represents a portion of the framing of the London Crystal Palace of 1851, showing the means adopted for getting it into position. This was effected by means of upright poles *a a* connected by a cross-piece *b*, and steadied by guys. The supporting columns were, by means of tackles attached to the cross-piece, hoisted into vertical position and there bolted, after which the girders were hoisted up in a similar way and secured to the columns.

B is an elevation, and *C* a plan of one of the cast-iron girders. They were 23 feet 3¼ inches long, and

Fig. 2230.



Paxton's Girders (Crystal Palace, London, 1851).

3 feet deep, and connected at top and bottom to the columns. Their great comparative depth enabled the latter to resist great lateral thrust, and imparted extreme stiffness to the structure, with the least possible weight.

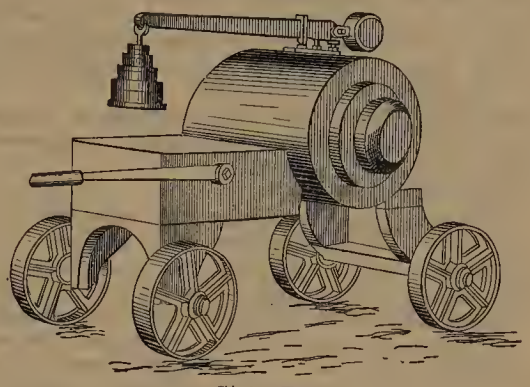
D is a form of wooden truss employed in the same structure.

Gird'er-bridge. A bridge supported by beams resting upon abutments at the ends. The beam is usually compound. A *truss-bridge*.

Gird'er-test'er. A form of hydrostatic press for testing the strength of girders. The form shown is on wheels, and has a safety-valve. By bolting two girders together, and placing this machine between them, they may both be tested at one time.

Gird'le. (*Diamond-cutting.*) The point of greatest marginal circumference of a *brilliant-cut* diamond, at which it is grasped by the *setting*. The projecting portion, rising about the *setting*, is the *bizet*, and has one third of the depth of the stone. It has thirty-two facets, and terminates in a flat face called the *table*. The imbedded portion of the stone has two thirds of the depth of the gem, and is called the *culasse*; it has twenty-four facets and terminates in a flat face, the *collet* or *culet*. See BRILLIANT.

Fig. 2231.



Girder-Tester.

Girt. A small girder. Used in roofs or bridge-frames.

A *girth*.

Girth. A band passing around the body. A *surcingle*.

More specifically: a band passing beneath the belly of a horse and buckled at each end to a girth strap of the saddle.

Girt-line. (*Nautical.*) A whip-purchase, depending from a lower-mast head and used in hoisting rigging and gear of the mast.

Gis-arm. A weapon formerly used. It had a long handle, a curved blade, and a prong projecting from the back of the blade.

Git. (*Founding.*) The entrance for molten metal into a mold. A *gate*.

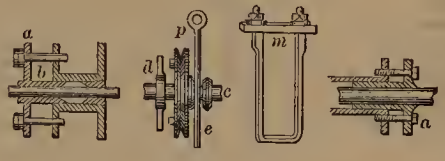
Gla'cis. (*Fortification.*) The superior slope of the parapet of the *covered-way*, forming a gentle slope towards the *country*, and protecting the *revetment* of the *scarp* from an enemy's fire. See BASTION.

Glad'stone. A four-wheeled, two-seated pleasure-carriage, with a driver's seat and dickey.

Glaire. (*Bookbinding.*) White of eggs. Used as a size in gilding.

Gland. 1. The cover of a stuffing-box. The cylindrical sleeve *b* presses upon the packing around

Fig. 2232.



Glands.

the piston-rod to make a steam or air-tight joint. The exterior flange *a* is perforated for the passage of the bolts by which the gland is tightened.

2. The common clutch consists of a loose pulley *p* which is slipped upon the shaft *c* by means of the lever *e*, so that the studs on the pulley engage with the *gland d*, which is fast to the shaft. This causes the motion of the pulley to be imparted to the gland and shaft. The contrary motion of the lever disconnects the power from the shaft.

3. (*Founding.*) A hooked bar by which the parts of a molder's flask are clamped together.

4. A plate *m* through which the ends of a band or tightening clevis pass. A clip-plate.

Glass. 1. Glass is a compound substance formed by fusing together mixtures of the silicates of potash, soda, lime, magnesia, alumina, and lead. The proportions vary in the different kinds of glass.

Silica fused with alkalies yields a transparent

glass; if the proportions of alkali and silica be as three to one, the compound is soluble in boiling water, and is called *soluble glass*, *water-glass*, or soluble silica. The greater the proportion of silica the less fusible is the compound.

Silica fused with lime, magnesia, baryta, or alumina yields an insoluble porcelainous compound, fusible only at a high heat.

Glass is divided into —

Flint-glass; used in making table ware and many articles of domestic furniture and fittings. The molten glass is taken from the pot by a *ponty*, and is blown or pressed into shape, or, by a combination of operations, is held in a mold while being blown.

Crown-glass is taken by the ponty from the pot, and is then blown and whirled till it becomes globular. A ponty tipped with molten glass is applied to the bulb, the blowing-tube detached, leaving a hole. The globe being again whirled, the glass flashes into a circular disk adhering by a boss in its center to the ponty. See CROWN-GLASS.

Sheet-glass. The glass withdrawn by the ponty from the pot is blown and whirled till it assumes a cylindrical form. The ends being cut off and the cylinder slit longitudinally, the sheet is heated, pressed, and rubbed until it is flattened out. This is also called *cylinder-glass; broad-glass* (which see).

Plate-glass is made by pouring it upon a table which has a marginal ledge of a hight equal to that designed for the thickness of the glass. A roller travels over the table, resting on the ledges and flattening out the glass, which is thus made of equal thickness throughout. See PLATE-GLASS.

Bottle-glass has nothing peculiar in the mode of its manufacture, but is made of coarse ingredients.

The proportions of materials in different kinds of glass vary with different places, as many notable proportions are, as it were, accidental; that is, are present in the sand which is most readily accessible, or are used to correct such faulty admixture. The following analyses are approximate: —

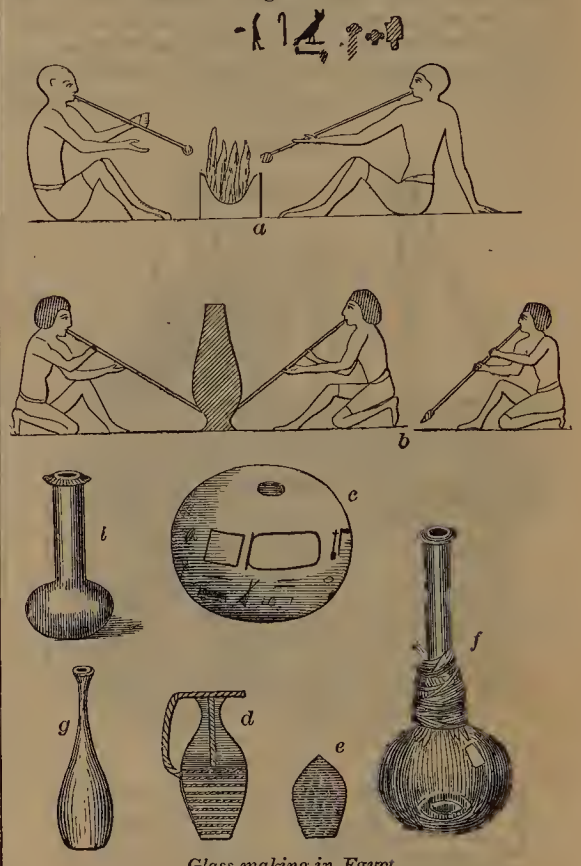
	Plate.	Broad.	Crown.	Flint.	Bottle.	Tube.	Optical.
Silica	78	69	63	52	59	73	43
Potash	2		22	14	2	12	12
Soda	13	16			10	3	
Lime	5	13	12		20	11	
Alumina	2		3	1	2	1	1
Oxide of lead				32			44
Oxide of iron		2		1	7		
	100	100	100	100	100	100	100

Glass was known in Egypt in the reign of Osirtasen, 1740 B. C. He may have reigned about thirty-four years when Joseph came to Egypt. In the tombs of Beni-Hassan of this date, the glass-blowers are shown at work (*a*), each with a bulb of glass on the end of his blow-pipe, into which he is blowing, while he keeps his glass hot by exposure to the fire. The same operation is depicted in other Egyptian tombs of various epochs. The glass at the end of the blow-pipe is colored green in the original painting.

Another representation (*b*) of the same process is shown in a tomb at Thebes, where one workman labors at the bulb of glass in the earlier stage of its formation, and two unite to inflate the bottle when it has acquired some size. In figure *i* is shown a glass bottle found in Thebes. The bottle came to represent wine in the hieroglyphics.

e shows a glass bead belonging to Captain Henvey, and the hieroglyphics contain the name of a monarch who lived 1500 B. C. The Egyptians attained an excellence in the manufacture of counterfeit amethysts and other precious stones which has not been excelled, and Winckelmann considers their skill in all departments of vitreous art to be in advance

Fig. 2233.



Glass-making in Egypt.

of any succeeding age. They made glass of various colors, imitation pearls, and two films of glass were made to inclose gold plates.

Athenæus states that the glass of Egypt was famous. Strabo says that one very perfect kind could only be made in Egypt.

Herodotus speaks of rings of melted stone (no doubt, glass) as decorating the ears of the sacred Egyptian crocodiles.

The manufactures of glass among the Egyptians were of bottles, vases, and other utensils, probably lamps; wine was brought to table in glass bottles, handed to guests in glass cups, and bodies were sometimes buried in glass coffins. They also made glass beads, charms, amulets, and images.

The inscriptions on the Egyptian articles of glass were probably cut by diamonds or the dust of diamonds or other hard gems. The Israelites learned the art from them, and from the skill thus obtained were enabled to engrave the stones in the breast-plate of the high-priest.

Some glass bottles among the Egyptians were inclosed by wicker-work like the *damagán* of Khorassan, a city of Persia, once famous for its glass-works. (Hence our *demijohn.*)

Others were covered with rushes like the Florentine flask. Others were partially covered with leather.

d is a bottle with a partial leathern cover.

e is a glass damagán.

f is a glass bottle encased in papyrus.

Remains of painted glass have been discovered in the ruins of Assyrian, Egyptian, Greek, Roman, and Etruscan cities.

In the magnificent collection, happily housed in New York, discovered and disinterred by General di Cesnola at Golgoi and Idalium, island of Cyprus, are nearly 2,000 specimens of Greek and Phœnician glass. The effect of decay or some rearrangement of the particles during the thousands of years of burial has rendered these articles dazzlingly iridescent.

"The boundless array of objects, reflecting from broad or curved surfaces tints positively outside of all experience, confuse the most accurate observation. Broad dishes, marbled with hues like those of incandescence; pots and jars and bottles, now plated over with strong surface-color like a coat of burnished metal, now sending light, pearly hints of variegated radiance, from elusive depths; or cups fantastically pied with scales of iridescence over their own strong original colorations, are scattered around a considerable apartment, defeating all sense of strict estimation, and cheating the mind with the notion of a possible perfection in the manufacture only compatible, as it seems, with decay. Some of the platters look as if Turner had painted skies on them in his maddest mood, and had been allowed to use flames for colors. The general effect seems to suggest that all the sunsets that have glimmered over Cyprus since these crystals were lost in the earth had sunk into their hiding-place and permeated their substance." — *N. Y. Nation.*

Most of the pieces are of simple inflated shapes, but some are pressed, having monograms and inscriptions in relief, opaque glass in mingled colors, sticks of twisted colors.

Small glass bottles from the Phœnician tombs, beneath the level of the Greek necropolis, show a reddish color when transmitting sunshine.

It would be tedious to enumerate the articles of glass found by Dr. Abbott in the tombs of Egypt. The myth related by Pliny and so widely copied in relation to the invention of glass-making by certain Phœnician mariners, has been exploded by researches in the land of the Nile. A few pieces in the collection may be noticed: —

Two beads of blue *glass* attached to a gold necklace stamped with the name of Menes, the first Pharaoh of Egypt (over 2000 B. C.).

A cylindrical ring of blue glass.

Glass bottles from Sakkarah, Gizeh, etc.

Glass beads, — white, blue, red, green, and black.

Variegated glass ornaments.

Semi-translucent glass imitations of alabaster.

Opaque red and blue glasses.

Tazzas and images of green, blue, and other colors.

Beads of colored glasses in layers.

Ornaments of mosaic glass.

A glass model of the crown of Upper and Lower Egypt.

Grotesque faces and portraits in glass.

Glass imitations of precious stones.

Glass rings of various colors.

Glass artificial eyes.

Glass spoons, shaped and colored in imitation of shells.

Layard, in his interesting work on Nineveh, says: "I was rewarded by the discovery of two small vases, one in alabaster and the other in glass, both in the most perfect preservation, of elegant shape and admirable workmanship." Each bore the name and title of the Khorsabad king, written in two different ways, as in the inscriptions of Khorsabad. The cuneiform inscription on one small green glass vase was to "Sargon," king of Assyria, the founder of Khorsabad, about 709 B. C. He also found a plano-convex glass lens 1½ inches in diameter and $\frac{9}{10}$ of an inch thick.

The lachrymatories (*g*) of ancient Phœnicia were of glass or pottery, and are found in great numbers on opening the tombs and sarcophagi of that land. Thompson records the opening of an ancient tomb in a garden of the city of Beirut, which contained scores of these tear-bottles in thin glass or unglazed pottery. They have a slender neck, a broad bottom, and a funnel-shaped top. David says: "Put thou my tears into thy bottle."— Psalm lvi. 8. These bottles are probably coëval with the sweet singer of Israel.

A record of the Phœnician trade on the western coast of Africa is still preserved in the peculiar glass beads found there.

The pillar of emerald seen by Herodotus in the temple of Hercules at Tyre (Book II. 44) was probably of glass. "Of all stones," says Pliny, "the emerald is most easily imitated" (XXVII. 12).

The Tyrians erected the first glass-houses mentioned in history, and practiced the manufacture for many ages before other contemporary nations attempted it. From Syria the art was brought by the Crusaders to Europe (1177), and established in Venice, which long had a monopoly therein and attained great excellence. See p. 976.

Theophrastus, the pupil and successor of Aristotle, notices the fitness of the sand at the mouth of the river Belus for the manufacture of glass.

Lucretius termed it *vitrum*.

Cicero mentions glass, linen, and paper as the common articles of Egyptian merchandise.

Scaurus, 58 B. C., introduced it in the scena of his gorgeous theatre, which was divided into three tiers: the lower of marble, the middle of glass, the upper of gilded wood.

The price of a glass drinking-cup in the time of Strabo was half an *as*. The *as* was about one cent.

The Museo Borbonico of Naples contains about 2,400 specimens of ancient glass, recovered principally from Pompeii and Herculaneum. They represent numerous forms of glass ornamentation in green, opal, blue, red, white, and yellow.

The Barberini vase, now known as the "Portland vase," was discovered about 300 years since, a short distance from Rome, in the tomb of Alexander Severus, who was killed by Maximinus, A. D. 235. The body of the vase consists of dark blue glass, on the surface of which are delineated in relief elaborately wrought figures of opaque white enamel. So admirably is it made that it was long supposed to be a genuine sardonyx.

Fictitious gems in glass were known in Rome, as were also mosaic glass, glass plates for paving, wall-lining, windows.

Lucretius (95 – 51 B. C.) accounted as follows for the fact that sound would pass through some objects while images would not: —

"The voice can pass unbroken through winding pores of bodies, *though* images refuse *to pass through them;* for the *latter* are broken to pieces unless they go through straight passages, such as those of glass, through which every image flies." (Book IV. 613–619.)

Opalescent glass is referred to by the Emperor Hadrian in a letter to the consul Servianus, thanking him for a present of three curious cups of glass which "reflected like a pigeon's neck a variety of colors."

Flexible glass is referred to by Pliny, Petronius, Dion Cassius, and others who copied from them.

The two former refer to vases made in the time of Tiberius. It is not fully credited.

Julius Cæsar found the Britons in possession of glass beads, which they probably obtained of the Phœnicians in return for tin. Rome had few glass windows till the reign of Nero. Some are found in the ruins of Pompeii, buried 79 B. C.

Pliny describes the mode of making glass, and states that Sidon was *formerly* famous for its glass-houses, and that its people first invented mirrors. In this day, says he (A. D. 79), throughout the Spanish and Gallic provinces, glass is made of white sand and niter by a double fusion. He also speaks of flexible glass, stating that "he hardly believed the story," which was a wonderful thing after telling such a farrago of stuff about medicines and magic. In his day — he says — glass had quite (? nearly) superseded the use of silver and gold for drinking-vessels.

He noticed the effect of lenses, stating that "globular, glass vessels, filled with water, when brought in contact with the rays of the sun, become heated to such a degree as to cause articles of clothing to ignite." He omitted to notice that the glass remained cool, and only transmitted and concentrated heat.

Previous to the introduction of glass into Europe in quantities to make it available for ordinary household use, a mineral substitute was employed.

Crystals of gypsum are generally in the form of more or less compressed rhomboids, which are easily divisible into thin laminæ by splitting them parallel to their two broad planes. Such laminæ were employed at Rome in the reign of Tiberius for many of the purposes for which we at present use glass. Spain and Cappadocia furnished the best, sometimes of the length of five feet. This variety of gypsum was known by the name of Lapis Specularis, from the use to which it was applied, namely, in glazing windows and conservatories in which were placed fruit-trees, to protect their produce from the winter's cold, and in the construction of beehives, as Pliny expressly informs us, for the purpose of enabling the curious to observe the proceedings of these interesting insects. The temple of Fortune at Prænestè was built of slabs of gypsum, through which the light came and fell on the statue of the goddess, which was placed in the center of the edifice. The *specular stone* of the ancients often signifies *mica*.

Glass panes for windows are mentioned in the writings of Gregory of Tours, who flourished in the last quarter of the sixth century. He stated that churches were furnished with windows of colored glass in the fourth century of our era.

Jerome, A. D. 422, states that glass was melted and cast into plates for windows. In the sixth century Paulus Silentarius notices that the windows of the Church of St. Sophia at Constantinople were glazed.

The oldest glass windows now in existence are of the twelfth century, and are in the church of St. Denis, France.

In the thirteenth century, the Venetians exceeded all others in glass-making.

Æneas Sylvius states that, in 1458, the houses in Vienna had glass windows. He regarded it as a sign of opulence.

In France, church windows were generally glazed in the sixteenth century, though there were but few glass windows in private dwellings.

Talc, isinglass, horn, oiled paper, and thinly shaved leather were generally used instead of glass throughout the civilized world.

Blue glass, colored by the addition of cobalt to the frit, was discovered about 1550 by Christopher Schurer of Platten, Bohemia.

Glass was imported into England, A. D. 1177; the manufacture was established in that country, 1557. In Savoy, the same year.

Plate-glass was made at Lambeth by Venetian artists, 1673.

The British Plate-Glass Company was established 1773.

An active manufactory of glass exists at Hebron, in the land of Palestine, — the same Hebron where is the cave of Machpelah, bought by Abraham for a sum of money of Ephron, one of the sons of Heth. The tombs are preserved in rigid seclusion from Jew and Christian; of the latter, not one lives in the town of 5,000 people. Dr. Thomson gives an account of it in his work, "The Land and the Book," but could not reach the vault.

The manufacture consists of party-colored glass bracelets for the Jerusalem market, and lamps for Syria, Palestine, and Egypt. The solid articles are formed from a bulb of glass adhering to the end of an iron, being shaped by the aid of a long knife. The glass is twisted, pressed into an approximate shape, then reheated and stretched by another rod.

The Crystal Palace of London was built in 1851, after the designs of Sir Joseph Paxton, soon after the abolition of the excise duty on glass, and was considered to celebrate that event in a worthy and effective manner. The roof and sides were, to a great extent, of glass, the sash being of wood, and the frame of the building a combination of wrought and cast iron. The following are some of the data and dimensions: —

Length	1,848 feet.
Width	408 feet.
Area roofed in	772,784 square feet.
Floor area of galleries	217,100 square feet.
Sash-bars	200 miles.
Glass	896,000 square feet.
Wrought-iron	448,000 pounds.
Cast-iron	8,512,000 pounds.
Visitors	6,039,195 persons.
Receipts	£506,100
Expenses	£292,794
Value of exhibited articles	£2,000,000
Number of exhibitors, —	
British	7,381
Foreign	6,556
	13,957

In 1838, Mr. Robert Lucas Chance, of Birmingham, England, successfully introduced the manufacture of Bohemian sheet-glass into his district. Mr. James Chance perfected the process of grinding and polishing sheet-glass, now known as *patent plate*.

"The 'London Builder' gives, as derived from an eminent member of this firm, the following record of improvements in the glass trade, during the last fifty years: —

"1. The substitution, about the year 1830, of carbonate of soda as the alkaline ingredient in glass in the place of kelp, and subsequently, for crown and sheet glass, of sulphate of soda in the place of carbonate.

"2. An increase in the size and improvement in the workmanship of the plates, sheets, and tables produced.

"3. An improvement in the color of the glass by the use of purer materials and modifications in the process of melting.

"4. Numerous improvements in the flattening

of sheet-glass, resulting in the removal or diminution of many imperfections.

"5. The use of the diamond in the process of splitting cylinders in the place of a red-hot iron.

"6. An increase in the size of the melting-pots and furnaces, with the view of economizing coal and labor.

"7. The adoption, in the casting of plate-glass, of various mechanical contrivances. The origin of some important improvements of this class is due to the present manager of the Birmingham Plate-Glass Company.

"8. The use of the same pot for the two processes of melting and casting plate-glass, superseding the old method of transferring the contents of the melting-pot into the vessel used for casting.

"9. The substitution of small coal or slack in the melting processes in the place of the large coal or lumps.

"10. The application of Siemen's regenerative process to the melting of glass, by which the amount of smoke is greatly diminished, the color of the glass is improved, a greater control is obtained over the furnace, and a saving of fuel is effected wherever, by this process, slack can be substituted for large coal or lumps. These advantages are to some extent counterbalanced by the increased cost of the furnace, and its increased liability to get out of order. The process, however, as applied to glass-making, is so new that there has been scarcely time as yet to overcome the difficulties which have presented themselves.

"Messrs. Chance are widely known for the production of dioptric apparatus for lighthouse illumination. Mr. Alan Stevenson remarks: 'Nothing can be more beautiful than an entire apparatus for a fixed light of the first order. It consists of a central belt of refractors forming a hollow cylinder six feet in diameter and thirty inches high; below it are six triangular rings of glass ranged in a cylindrical form, and above, a crown of thirteen rings of glass, forming by their union a hollow cage, composed of polished glass ten feet high and six feet in diameter. I know of no work of art more beautiful or creditable to the boldness, ardor, intelligence, and zeal of the artist.' More than one hundred and fifty of these dioptric lights have already been produced by Messrs. Chance, for almost all parts of the world."

A vitreous, opaque material, called from its translucent, milky appearance, "hot-cast porcelain," is now made in Philadelphia. It is understood to be made from cryolite or feldspar, whose natural and added fluxes render them fusible at a comparatively moderate temperature, yielding a mass viscid and tractable while hot, lustrous and strong when cold.

It was proposed to make the headstones for the graves of Union soldiers of this material. One side of the mold would have a tablet in which the letters of the inscription would be set up. It would seem to be impossible to find an equally good material for the purpose. Glass (ordinary), marble, or enameled iron are inferior and more frangible.

Plates of ice are used instead of panes of glass in the Siberian *yurts*, or winter-quarters, which are partly subterranean.

(*Optical Glass.*) Crown and flint glass are combined in the construction of achromatic lenses. The former of these is a compound of silex, potash, and lime; the latter contains in addition oxide of lead. This tends to sink to the bottom of the melting-pot, rendering the glass of unequal texture and consequent refracting power. In this consisted the principal difficulty in obtaining object-glasses of large size. So late as 1830, the largest object-glasses of satisfactory performance which were produced did not exceed five or six inches in diameter. Previous to this, however, Guinand, a melter in a glass-manufactory at Soleure, in Switzerland, succeeded in making large disks, but he kept his process secret, and died without disclosing it, though it continued to be practiced by his son and afterward by M. Pfeil of Paris, who exhibited at the Exposition of 1867 a disk of the diameter of 72 centimeters, — over 28 inches. The process of making these disks consists substantially in uniting numerous small selected masses of uniform density and refracting power into one large mass by pressure while in a plastic state. In 1855, Messrs. Chance of Birmingham exhibited at the Exposition of that year a pair of disks, crown and flint, about an inch larger than those of M. Pfeil. See LENS.

2. (*Nautical parlance.*) *a.* A telescope.

b. The barometer.

c. The half-hour or sand-glass which regulates the watches.

d. The half-minute or quarter-minute sand-glass used with the ship's log.

See under the following heads: —

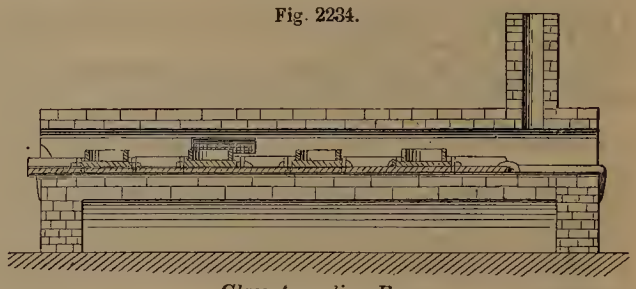
Adapter.
Amaasa.
Anaclastic glass.
Annealing arch.
Argentine-glass.
Aventurine-glass.
Balloon.
Bead.
Beaker.
Bell-glass.
Binocular glasses.
Blebby-glass.
Blowing-iron.
Blow-over.
Blowing-tube.
Bocal.
Bocca.
Boccarella.
Bohemian-glass.
Bologna-vial.
Bolt-head.
Bombolo.
Bottle.
Bottle-glass.
Bottle-holder.
Bottle-stopper.
Bottoming-hole.
Broad-glass.
Bruiser.
Bugle.
Bull's-eye.
Bunting-iron.
Burning-glass.
Calcar.
Calx.
Came.
Capping-off.
Cap-pot.
Carboy.
Carquaise.
Casher-box.
Casting-slab.
Casting-table.
Cave.
Cheval-glass.
Circulus.
Cistern.
Cranny.
Crown-glass.
Cryolite-glass.
Crystal.
Cullet.
Cupping-glass.
Cut-glass.
Cuvette.
Cylinder-glass.
Drop.
Egg-glass.
Email ombrant.
Embossing-glass.
Emerill.
Enameled-ware.
Eye-glass.
Fascet.
Ferret.
Ferretto.
Field-glass.
Filigree-glass.
Fine-arch.
Firing.
Fish-globe.
Flacket.
Flashing.
Flatting.
Flatting-furnace.
Flint-glass.
Flux.
Frache.
Fret-work.
Frit.
Frit-brick.
Fritting-furnace.
Frosted-glass.
Fusible-porcelain.
Gage-glass.
Gem. Artificial
Gilding-glass.
Glass.
Glass annealing-furnace.
Glass-blowing.
Glass-cement.
Glass-coach.
Glass-coloring.
Glass-cutting.
Glass-enamel.
Glass-engraving.
Glass-furnace.
Glass-gall.

Glass-grinding.
Glass-house.
Glass-maker's chair.
Glass-maker's soap.
Glass-metal.
Glass-mold.
Glass-mosaic.
Glass-oven.
Glass-painting.
Glass-paper.
Glass-polishing.
Glass-pot.
Glass-press.
Glass-rolling.
Glass-silvering.
Glass-soldering.
Glass-spinning.
Glass-staining.
Glass-tongs.
Glazier's diamond.
Glazing-tool.
Glory-hole.
Graduated-glass.
Grozing-iron.
Ground-glass.
Hand-glass.
Harbor.
Hopper.
Horizon-glass.
Hour-glass.
Index-glass.
Knob.
Lamp-chimney.
Lead-light.
Leer.
Lens (varieties, see LENS).
Lens-grinding.
Log-glass.
Looking-glass.
Lunette.
Magnifying-glass.
Marver.
Massicot.
Matted-glass.
Metal.
Milk-glass.
Millefiore-glass.
Minute-glass.
Mirror.
Mosaic-glass.
Mouth-glass.
Mucilage-bottle.
Multiplying-glass.
Nose-hole.
Object-glass.
Omnibus.
Opaline.
Ouvreaux.
Paste.
Perspective-glass.
Phial.
Pier-glass.
Pinching-tongs.
Plate-glass.
Platenizing-glass.
Plattening-glass.
Poling.
Polishing-glass.
Polverine.
Pontil.
Potichomanic.
Pot-metal.
Pressed-glass.
Priscillas.
Pucellas.
Pulse-glass.
Quarrel.
Quarry.
Reticulated-glass.
Runner.
Sadwei.
Sand-blast.
Sand-glass.
Sandiver.
Sand-washer.
Schmelze.
Shanks.
Sheet-glass.
Sheet-glass machine.
Shell.
Siege.
Silvering-glass.
Singing-glass.
Skylight.
Smetz-glass.
Smoke-bell.
Snap.
Snapdragon.
Soluble-glass.
Spreading-furnace.
Spreading-plate.
Spring-tool.
Spy-glass.
Square.
Stained-glass.
Storm-glass.
Strap.
Strockle.
Table.
Template.
Test-tube.
Tin-glass.
Tisar.
Vault-light.
Venetian-ball.
Venetian-glass.
Vial.
Vitrics.
Vitrio-de-Trino.
Watch-glass.
Water-glass.
Weather-glass.
Window-glass.

Glass An-neal'ing-fur'nace. One in which articles or sheets of glass are kept for a while in a heated condition, and allowed gradually to cool. A *leer*. (See ANNEALING.) In the illustration, which is a *leer* for glass jars, the trays of ware are put into the arch at one end and pushed in succession to the discharge-end. The heat of a furnace is thrown into the *leer* at a point between feed and discharge ends, so that the heat is graduated both ways.

Glass-blow'ers' Lamp. A gas or alcohol lamp. See BLOW-PIPE.

Fig. 2234.



Glass Annealing-Furnace.

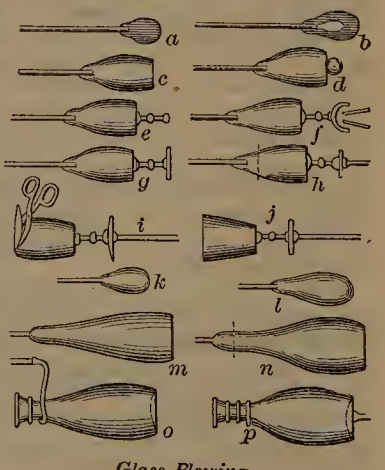
Glass-blow'ing. A mode of manufacturing glass-ware and window-glass by taking a mass of viscid glass from the melting-pot on the end of the blowing-tube, and then inflating the mass by blowing through the tube, rolling on the *marver*, and exposing it at the furnace opening where its contained air is expanded and itself enlarged. Glass-blowing enters into most of the operations with glass, but the process is modified to suit varying circumstances. See CROWN-GLASS; CYLINDER-GLASS; FLINT-GLASS, etc.

Glass-blowing is also used in connection with molds, which give the exterior form to the article, and in the ingenious operations of making glass articles and toys under the BLOW-PIPE (which see).

The art of glass-blowing long reigned supreme at Murano, one of the islands of the maritime city Venice. After some preliminary matters, an observer states: —

"At the present moment you may set before Antonio Seguso or Antonio and Giovanni Barovier, of Murano, any specimen of old Venetian glass, and they will copy it with all its perfections, and, if you choose, its imperfections, and hand you a fac-simile in color, form, and *weight*, made under your own eye. On my first visit, the head workman was requested by Salviati to make me any article I might fancy. I chose a wineglass with deep bowl, initial stem, and broad, ruby-tinted foot. The man dipped his hollow iron rod into a pot of molten white glass, caught up a lump, rolled it on an iron slab, popped it into the furnace, blew through his rod, tossed it aloft, and a hollow ball appeared. His assistant handed him a rod of metal, in which a green serpent seemed coiled in a white cage; this he caught, and, quick as lightning, formed two initials, touching the bowl with the tip of the M, to which it adhered, Then his assistant offered more white glass, which was joined to the bottom of the M, spun round, opened with the nippers, and so the foot was formed. Again into the furnace, and then the shears opened and hollowed the deep and slender bowl. Then the assistant handed a scrap of ruby molten glass, of which the master caught a hair, as it were, wound it round the rim of the bowl and of the foot. Once more into an upper oven, where it must remain till the morrow to cool."

Fig. 2235.



Glass-Blowing

Fig. 2235, *a* to *j* show the forms assumed by a ball of molten glass in the manufacture of a wine-glass. *a* shows the ball as taken up on the point, heated nearly to redness, of the blowing-iron. After being rolled on the marver and slightly expanded by blowing, it takes the shape *b*, when it is farther shaped and flattened by the battledore, as represented at *c*; a solid ball is then attached *d*, which is by the lathe or the use of the pucellas while being rotated on the glass-maker's chair formed into the stem *e*. To this a globe is attached, which is opened out and flattened by the pucellas while being rapidly rotated on the chair constituting the foot, as shown at *f g*. A small knob of glass is now by means of the pontil attached to the foot *h*, after which the cold pucellas are applied at the dotted line shown in *h*, after which the bowl is sheared *i* preparatory to flashing and finishing. The finished glass *j* is then taken up by means of a forked rod and transferred to the annealing arch.

In making a ringed decanter, the ball *k*, after being slightly distended, is swung round, causing it to assume the shape *l*; this is farther expanded and battledored at the end, taking successively the forms *m n*, the pontil is attached to the bottom and the neck broken off at the point indicated by the dotted line, and the mouth warmed up and shaped. The rings are formed by taking up small quantities of glass on the pontil and applying them as shown in *o p* to the neck of the decanter, which is rotated for the purpose.

Glass-ce-ment'. To stop cracks: —

Dissolve caseine in cold saturated solution of borax, and with this solution paste strips of hog's or bullock's bladder (softened in water) on the cracks of glass, and dry at a gentle heat; if the vessel is to be heated, coat the bladder on the outside, before it has become quite dry, with a paste of a rather concentrated solution of silicate of soda and quicklime or plaster of paris.

To unite broken parts: —

Two parts isinglass are soaked in water until well swollen, the water poured off, and the isinglass dissolved in warm alcohol; one part mastic is dissolved in three parts alcohol and added to the above solution, then one part of gum ammoniacum is added. The solution is well shaken and evaporated to the consistency of strong glue, then allowed to cool and solidify. When used, both cement and articles to be mended must be warmed. See also p. 507.

Glass-cloth. (*Fabric.*) A fabric produced by interweaving fabrics of glass, which are, in a very attenuated state, extremely flexible.

Glass-coach. A carriage of the superior order. The term is nearly obsolete, but it originally expressed that the vehicle had glass windows instead of opaque panels or curtains.

Glass-col'or-ing. Tinting glass by incorporating metallic oxides in its substance.

Articles which exhibit different colors upon the same specimen, and at different depths in the thickness of the glass, are formed by dipping the article, first made in white, transparent glass, into a pot of fused, colored glass. A coating adheres, and is afterwards cut away in portions, so as to expose the clear glass.

The colors are obtained by the following: —

Oxide of cobalt imparts deep blue.

Dioxide of copper imparts ruby red.

Protoxide of copper imparts green.

Protoxide of iron imparts shades of green.

Peroxide of iron imparts yellow brown.

Oxide of gold imparts ruby red.

Yellow oxide of iron, muriate of silver, oxide of zinc, and white clay, impart a yellow tinge; oxide of cobalt, oxide of manganese, and oxide of iron, impart a black tinge.

Red oxide of iron prepared by nitric acid and heat imparts red.

Purple of Cassius, precipitated from muriate of gold by protomuriate of tin, imparts violet.

Oxide, chloride, or phosphate of silver imparts yellow.

Peroxide of manganese imparts a shade of violet.

Oxides of chromium impart shades of green and red.

Uranium imparts opalescent yellow.

Binoxide of tin imparts opalescent white. In excess, opaque enamel.

Arsenic imparts bluish-white opal with changeable red tints.

Green may be obtained by staining one side of the glass blue, the other yellow.

Orange by similar combination of red and yellow.

Colored glass is known as *flashed*, or as *pot-metal*: in the former case a film of colored glass is laid over the white; in the latter, the color is stirred up with the *metal* in the pot, imbuing its whole substance.

Glass-cut'ting. Glass was known to the ancient Egyptians and Assyrians, and the art of gem-cutting was also known; the engraved gems of the Jewish high-priest's breastplate were cut by artists trained in Egypt.

Glass was cut upon a lap by the Greeks, and Pliny refers to the same, Book XXXVI. 26.

It has been affirmed that the art of glass-cutting was invented at the beginning of the seventeenth century by one Caspar Lehmann, of Prague, who was patronized by the Emperor Rodolphus II. Schwanhard, an apprentice of Lehmann, removed to Nuremberg, where he worked for many of the principal nobility, and hence this city acquired the reputation of being the birthplace of the new art; which was afterward much improved by the introduction of new tools and cheaper methods.

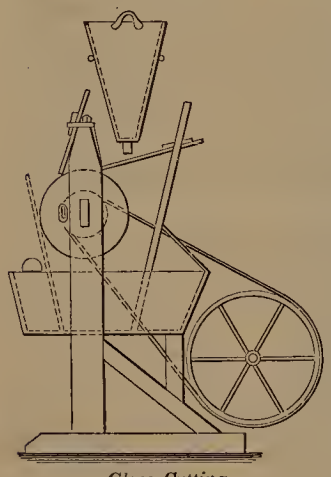
Previous to this, however, figures had been cut or engraved on glass by means of the diamond. The first mention of writing on glass with the diamond only dates back to the time of Francis I. of France (1520), but about the year 1562 festoons and other ornaments cut with a diamond were very common on Venetian glasses, which at that period were accounted the best.

What is known commercially as "cut-glass" is glass with incisions and ornaments with smooth surfaces, appearing as if cut by a sharp instrument. This operation is chiefly confined to flint-glass, which, being more tough, soft, and brilliant than the other kinds, is more easily wrought, and produces specimens of greater luster. An establishment for cutting glass contains a great number of small wheels, of stone, metal, and wood, which are made to revolve rapidly, by a steam-engine or other power. The cutting of the glass consists entirely in grinding away successive portions, by holding them upon the surfaces of these wheels. The first or rough cutting is sometimes given by wheels of stone, resembling grindstones. Afterward, wheels of iron are used, having their edges covered with sharp sand, or with emery, in different states of fineness. To prevent the friction from exciting so much heat as to endanger the glass, a small stream of water continually drops upon the surface of the wheel. The last polish is given by brush-wheels, covered with putty-powder, which is an oxide of tin and lead.

The customary grinding and polishing of glass articles for various uses is effected by revolving

wheels of iron, stone, or wood, horizontally mounted, and supplied with a stream of water from a hopper or can above the wheel. The water is led by a sloping channel to the upper edge of the wheel, and a slightly sloping board is placed just in front of the point of its delivery to distribute it equally over its edge. A splash-board in front catches the water as thrown off by centrifugal force, and leads into a trough beneath. A second splashboard is sometimes placed in front to protect the workman from wet. The wheels employed are generally from six to twenty inches in diameter; they are mounted on separate spindles, so as to be exchangeable, and have flat, rounded, angular, or concave edges.

Fig. 2236.



Glass-Cutting.

The two former are used for producing the flat or slightly concave faces of the work, called *flutes;* the angular produce the angular grooves or *splits* on the sides of decanters and similar objects, and the concave form the convex ribs called *pillars.* The wheels for first or rough grinding are of iron, and a considerable quantity of sand is employed; the work is then smoothed upon fine grit stones, rendered circularly true and very smooth, less water and no sand being used; after which they are polished upon wooden wheels with pumice and rottenstone and water, and the final luster imparted by wet putty-powder applied on similar wheels.

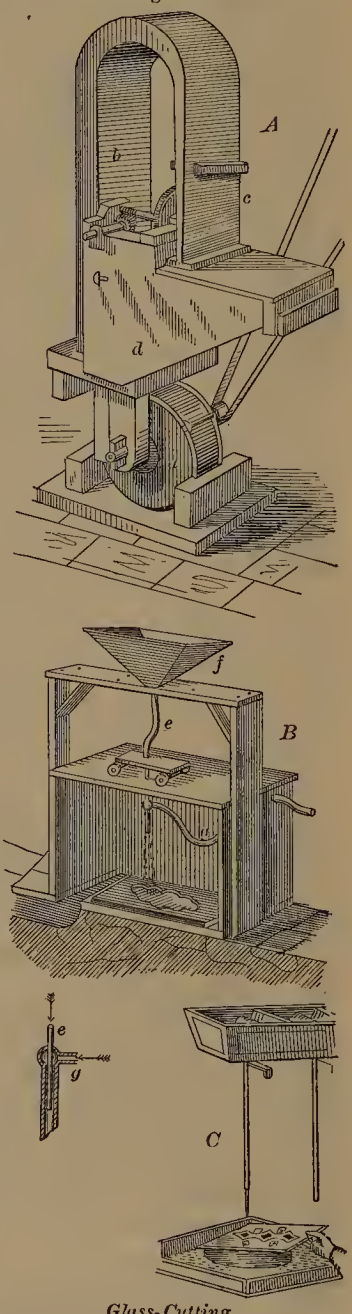
Tilghman's process for cutting glass or stone by means of a blast of air or steam carrying a stream of sand is adapted for piercing or for engraving the surface, and has many adaptations. In Fig. 2237, *A* is an apparatus for roughening sheet-glass. The air-blast is produced by the fan *a* below, and the air rises through the curved tube *b*, carrying the sand up with it, which is thrown into the air-tube by an endless belt of scoops arranged in the lower part of the angular box *d*. The sand is carried up by the air and brought over and down the front air-tube *c*, where it discharges with great force upon the surface of the glass, which is contained within the front box, and is carried by a belt gradually forward under the sand blast. The sand falls from the glass into the lower part of the angular box, whence it is scooped and thrown again into the air current.

Another form of apparatus for boring or engraving is shown at *B*, and the sand is driven in this case by steam, on the principle of the injector. The sand descends through a tube *e* from the hopper *f*, and in its course the vertical sand-pipe is joined by a lateral steam or air pipe, which gives a sudden impulse to the sand and drives it down upon the glass below with great force. The sand-tube is flexible, its extremity is carried on rollers, by which it may be moved back and forth to suit the requirements of the work.

C is still another form, in which corundum-powder is dropped from a hight upon the surface of glass to roughen or engrave it.

In each of the cases cited, the abrading material is directed by a tube upon the part desired to be bored or cut, the plate, if necessary, being moved beneath the sand-blast so as to bring each part in succession under the action of the cutting particles. When a pattern is to be engraved, a portion of the surface is protected by paper, oil-paint, a sheet of rubber, cloth, or lace, as the case may be. The sand bounds from these resilient materials, but indents the glass or stone with its points and edges, so as to roughen and gradually wear away the face, or even bore through it if the process be long continued. With a steam jet of 300 pounds' pressure, a hole $1\frac{1}{2}$ inches in diameter was cut through a piece of corundum $1\frac{1}{2}$ inches thick in 25 minutes. The rate is dependent upon the hardness of the material to be cut, the force of the blast, and the sharpness of the powder; the latter is much dependent upon its hardness, as corundum will outwear mere quartz sand.

Fig 2237.



Glass-Cutting.

This beautiful process has many applications. Glass partially protected by a fern-leaf receives a frosted ground leaving a bright leaf; protected by wire gauze it may be turned into glass gauze. Ornamental letters may be made on glass, marble, or granite, either bright on a rough ground, or conversely. It has even been used to etch through negative films of bichromated gelatine, the penetration being greater in proportion to the thickness and hardness of the film.

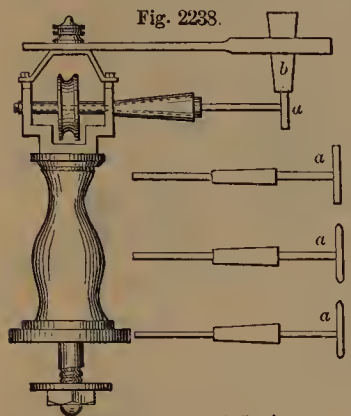
Glass may be cut by a jet of hot air or gas, directed upon the object in the line of the desired fracture. This is then damped, and the glass contracts and divides on the line. The same may be done by a hot poker carried along the line to be broken; commence with a file cut to start the crack, apply the poker and the crack will follow the iron.

Glass may be readily drilled by a hard steel drill kept moist by turpentine. Dilute sulphuric acid or carbolic acid are good lubricants. It is said that at Berlin glass castings for pump barrels are drilled, planed, and bored like iron ones, and in the same lathes and machines, by means of sulphuric acid. See also GLAZIER'S DIAMOND.

Glass-en-am'el. This is applied to a semi-lucid or an opaque glass, which owes its milkiness to the addition of binoxide of tin. The transparencies which are hung in windows or form shades for lamps are of the semi-lucid character, and are miscalled *porcelain transparencies.* Watch-dials have an opaque, glass-enameled face on a metallic backing. See ENAMEL.

Glass-en-grav'ing. The engraving of flint-glass is substantially the same as the ordinary glass-cutting, but is of a more delicate character. It is effected by the use of very small disks, generally of copper, and moistened at the edges with emery and oil.

Fig. 2238.



Glass-Engravers' Lathe.

Bodier's improvements (French) in glass-engraving were made in 1799. The engraver sits at a small lathe with a little rack before him, containing about a score of the copper disks, varying in size from the diameter of a cent down to one-fiftieth of an inch, each mounted on a spindle and sharpened on the edge. He paints a rough outline of the design on the surface of the glass, and selecting a disk he touches the edge with emery and oil, inserts it in the mandrel, sets it spinning, and holding the glass against it from below, the little wheel eats its way in with astonishing rapidity. The glass, held lightly in the hands, is shifted about continually, till all the greater parts of the figure are worked out; then, for the lesser parts, a smaller disk is used; and at last the finest touches, such as blades of grass, the tips of antlers, eyebrows, and so forth, are put in with the smallest. Every minute he holds the glass up between his eye and the light, watching the development of the design; now making a broad excavation, now changing the disk every ten seconds, and giving touches so slight and rapid that the unpractised eye can scarcely follow them.

The illustration shows the lathe-post with its band-pulley, spindle, and disk *a* in position. *b* is a slip of wood mounted on an arm, and designed to keep the wet powder from being thrown against the operator. For polishing, a leaden disk and pumice-powder are used.

Glass-fur'nace. There are several furnaces in a house for making *crown-glass:*—

The *reverberatory-furnace*, or *calcar*, for fritting or calcining the materials. Also known as the *fritting-furnace.*

The *glass-furnace* containing the pots in which the materials are melted.

The *blowing-furnace*, at which the pears of glass are enlarged into globes.

The *bottoming-hole*, where the globe is flattened.

The *flashing-furnace*, where it is expanded into a circular plate.

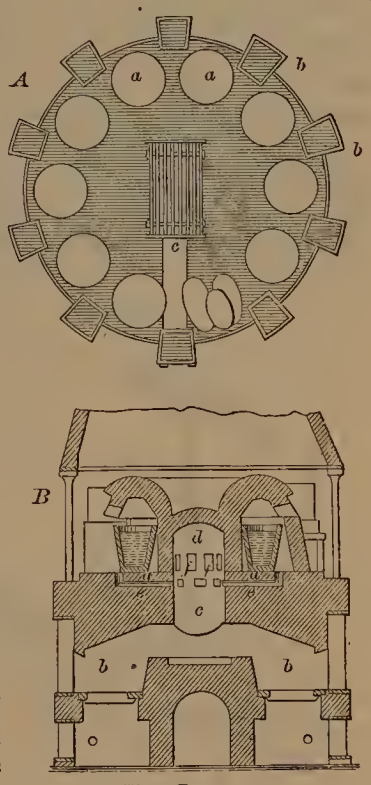
The *annealing-arch* or *leer*, where it is allowed to cool gradually.

The *reverberatory-oven*, where the pots are heated and seasoned.

Fig. 2239, *A* is a plan of the furnace in which the frit in pots is converted by fusion into glass.

a a, etc., are the flues between which the pots are placed, resting on the intervening spaces, so that each flue heats one side of two pots. The working holes *b b*, etc., are opposite each pot and between the flues. *c* is the grate. Flame and smoke pass through apertures called *linnet-holes* at the upper part of the sides of the furnace, which has a dome-shaped top. The furnace *B* has an annular bed with projections *a a* on which the crucibles rest. It is provided with two fireplaces *b b* communicating with a central flue *c*, through which the caloric current passes to an upper chamber *d*, whence it is distributed to the crucibles by the openings *e e f f.*

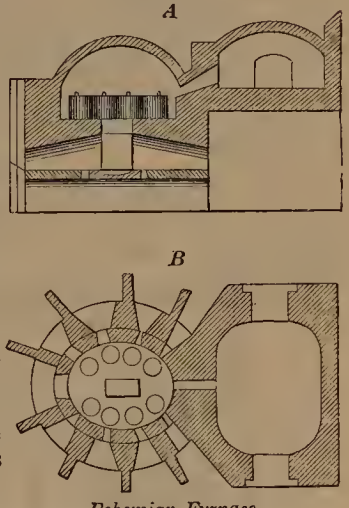
Fig. 2239.



Glass-Furnaces.

Fig. 2240, *A* is a longitudinal section, and *B* a plan of a Bohemian furnace employed in making window-glass. Above the vaulted ash-pit is the fireplace, having three compartments from which the heat passes through a central opening to the oven containing the glass-pots, which are placed closely together for economy of space. The pots are introduced through a front opening which is then bricked up. The working-holes are between the pillars of the structure. A flue conducts the heat to the annealing-stove, exterior to which is usually a drying-kiln, not shown in the figure, and there are adjoining stoves called *arches* for drying and annealing new pots.

Fig. 2240.



Bohemian Furnace.

Glass-gall. Scum on the glass, in the pot. *Sandiver.*

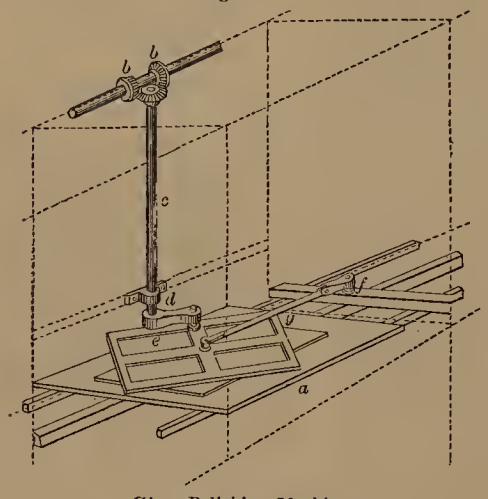
Glass Grind'ing and Pol'ish-ing. Plate-glass from the table requires grinding and polishing, which is performed by machinery. The under plate is imbedded in stucco on a solid table, and the upper one in a cast-iron frame, which has a motion around its own center and around a point on the lower plate. The latter is on a movable table, and has a slow motion in the direction of its length and its breadth. Moistened sand is applied between the two. Afterwards different grades of emery are used.

The polishing is effected by rubbers of hat felt or leather, with a paste of colcothar and water. Finally, a putty, oxide of tin, is used.

Fig. 2241 illustrates a machine for grinding and smoothing the plates to a true and even surface preparatory to finally polishing them.

The dotted lines indicate the framework of the machine supporting the bed *a*, to which a sheet of glass is cemented. Two bevel wheels *b b* rotate the axis *c*, which carries the crank *d* attached to one side of the movable table *e*, imparting to it a circular motion about the point *f*, where the radius-rod *g* is

Fig. 2241.



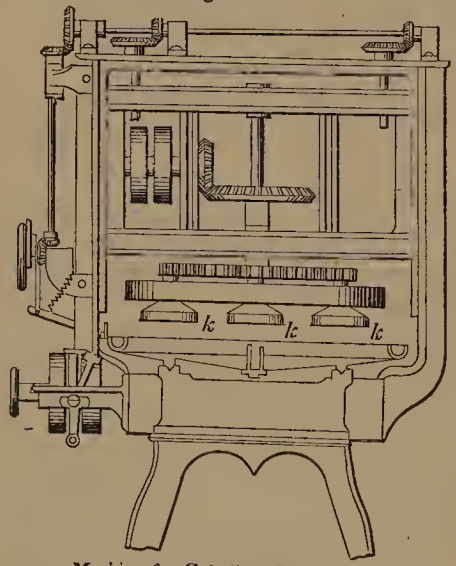
Glass-Polishing Machine.

pivoted; the bed *a* also has a slow longitudinal reciprocating movement imparted from a bar beneath. The lower part of the table *e* is faced with slate, to which a sheet of glass is cemented. Clean sharp sand and coarse emery are used for grinding, and finer emeries for smoothing; the apparatus being carefully washed at each change from coarser to finer material.

By the combined rotary and longitudinal movement the abradants are caused to operate with equal energy on every point of the plates. Weights are placed upon the back of the table *e* to insure sufficient pressure.

The final polishing is completed by leather-covered

Fig. 2242.



Machine for Grinding Glass Plates.

rubbers attached to reciprocating rods; the glass being fixed upon a table having a slow transverse movement so as to present every part of the surface of the glass successively to the rubbers.

Old plate-glass is usually repolished by hand, the rubber being attached to the lower end of a pole suspended from a horizontal spring overhead, which gives an adequate pressure on the glass, the workman having merely to push the rubber backwards and forwards. The polish attained in this way is inferior to that produced by machinery.

Fig. 2242 shows a glass grinding-machine in which the plate to be ground is held upon a reciprocating table under the rotary grinders *k k k*, whose supporting frame is capable of vertical movement in guide-ways, an automatic downward movement being imparted to the grinders at the end of each movement of the carriage by the action of gearing upon the screws on which the frame is hung.

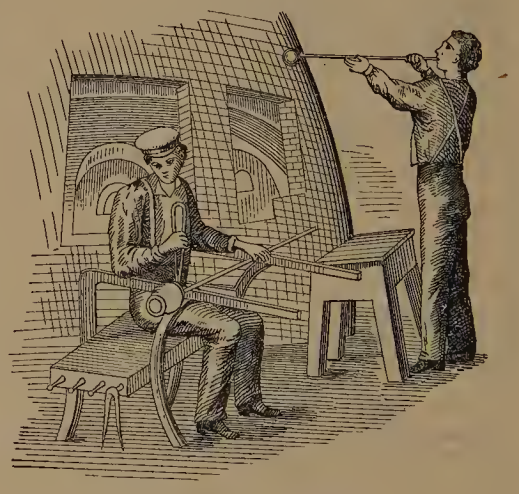
Glass-house. A place where glass is made.

Glass'ing. (*Leather.*) The operation of dressing leather on the grain side by a tool consisting of a glass slip set in a wooden handle.

Glass-lined Pipe. One in which the metal of the outer pipe is protected from corrosion by any liquids, except strong alkalies, or hydro-fluo-silicic acid. The glass lining is held in the outer metallic pipe, which is usually of iron, by an intermediate lining of cement, or plaster of paris, or similar substance, which lining serves to hold the glass in place and protect it against injury from unequal expansion of the glass and metal, besides acting as a non-conductor of heat.

Glass-mak'er's Chair. A seat having two arms upon which a glass-blower rolls with the left hand

Fig. 2243.



Glass-Maker's Chair and Marver.

his pontil or blow-tube, while with his right he fashions the bottle, lamp-shade, or other article he is making, by means of the *pucellas*.

Glass-mak'er's Soap. A name given to manganese, from its cleansing action in its association with glass-making materials.

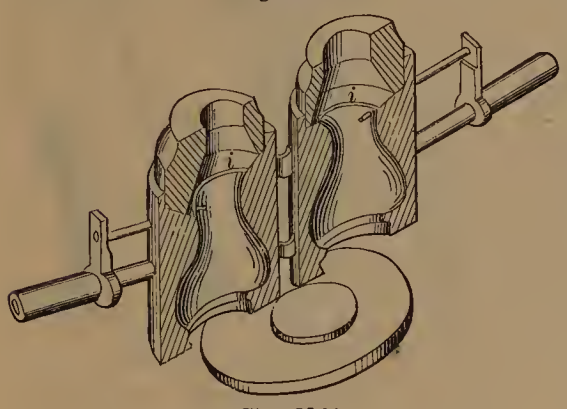
It is used to rid the materials of color arising from carbonaceous matters and protoxide of iron. An excess of it gives a purple tinge to the glass; much admired by some, and supposed — by some — to have a specific effect in urging vegetation in conservatories.

Glass-met'al. Glass in fusion in the pot.

Glass-mold. A metallic shaping-box in which glass is pressed or blown to form. In the case of solid articles, the glass for the knob or ornament is

placed in a plastic condition in the mold, and then a plunger drives it forcibly into all the recesses of the mold. After a few moments of "setting," the mold is opened, and the object is taken out and carried to the annealing-oven. This is the usual mode of making glass insulators for telegraph-wires, paper-weights, drops for chandeliers, and the solid kind

Fig. 2244.



Glass-Mold.

of inkstands where the glass is so much in excess of the ink-hole. The latter is made by a plunger, which is driven into the plastic glass in the mold. See GLASS-PRESS.

Hollow articles, such as fruit-jars, may be made by blowing (see GLASS-BLOWING), the *blowing-tube*, *chair*, and *marver* being the principal tools employed, the jar being held by its lip end while being blown, and then by transferring the *pontil* to the bottom while the lip is finished by the *shears* or the *pucellas*, or the jar may be grasped by the *snap-dragon*, if preferred.

The modern fruit-jar has usually some arrangement for locking down the lid or cover, and involves a threaded neck or one with lugs or projections. These can be made by tongs, which clasp the neck of the bottle, but not so readily as by clamping the bulb of glass in a mold and then blowing it so as to expand fully against all parts of the interior of the latter. The mold is then opened, and the formed article removed to the *leer*. Fig. 2244 shows a glass-mold open, the side parts being hinged together over the plate which forms the bottom. In this example, the shoulder *ircally* forms the lip of the ware, and the flaring recess above it is the *blow-over*, in which superfluous glass is received, the shoulder affording a thin point where the portion readily breaks off.

Fig. 2245.

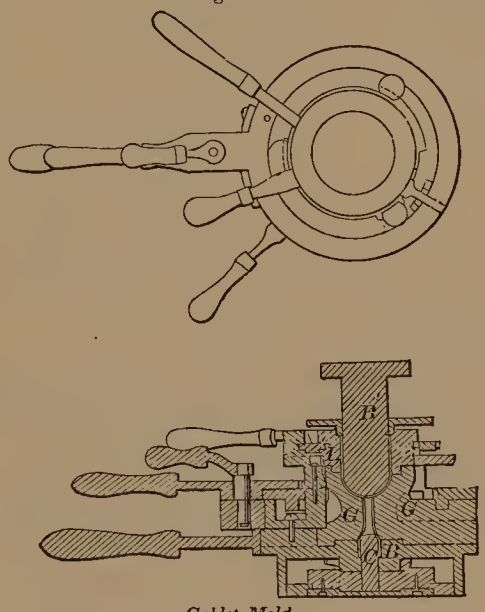
Glass-Blowing in Mold.

Fig. 2245 shows the man at work. He has taken the pontil from the boy, who had dipped the proper amount of glass out of the pot in the furnace, and had blown it partially and rolled it on the *marver;* the workman blows it still farther, rolls the pontil on the chair-arm while he fashions it by the shears, which are seen lying on the bench, and then slips it into the open mold and closes the latter by a spring while he blows it to its final expansion.

In some cases water is made to circulate through the molds, to abate the heat and allow the work to proceed more speedily. Molds are sometimes made to be closed by a treadle. See Plate XX.

Fig. 2246 shows a mold for making tumblers, — foot, stem, and bowl. The complication of form and the hollow character of the bowl require that a number of parts shall be employed, so that the ware may be taken out after molding. The foot is molded in cup form by the plunger *C* and matrix *B*, and is afterwards expanded. The stem-mold consists of three sections *G G*, which open radially over

Fig 2246.



Goblet-Mold.

the foot-mold. The body matrix *L* is held down upon the stem sections by a clamp. The portions have separate handles. For bottles which contain the names of the contents and medicines, the interior surface of the mold has intaglio engraving with the inscription, medallion, and what not.

Glass Mo-sa'ics. Glass mosaics are constructed as follows: —

In the first place, the materials of glass are mixed with various coloring materials, chiefly metallic oxides, so as to form opaque colored enamels; these enamels are cast into slabs or flat cakes, and the slabs are cut into very small cubes or rectangular pieces. Not only is every color imitated, but every gradation of tint in each color, insomuch that at the great mosaic establishment at Rome, maintained by the Italian government, they have no less than *thirty thousand* different tints of colored enamels, all classified and registered. With these little colored cubes a picture is built up, copying some celebrated work of the Italian or other masters. The pieces are inserted, one by one, in a bed of cement, which dries to extreme hardness; each piece is ground at a kind of lathe to the exact shape required by the particular tint in each part of the picture; and when the picture is completed by this extremely slow process, the surface is ground down and polished.

The two specimens of glass mosaic described by Winckelmann and Count Caylus, in the last century,

seem to have been of a somewhat different kind, for they presented a complete picture on each surface. They consisted of colored glass fibers fitted together with the utmost exactness, and cemented by fusion into a solid mass.

Glass-ov'en. A heated chamber in which just-made glass in sheets or ware is placed to cool gradually. A *glass-annealing furnace;* a *leer.* See ANNEALING.

Glass-paint'ing. *Glass-painting* is thus distinguished from *glass-staining:* the former has a design painted upon it with colors which are burned in; the latter receives its color in the process of manufacture, or the separate pieces are colored after having been cut to the required shapes out of white glass.

In one case it is a painting of enameled colors on sheets of glass.

In the other, it is a painting made up of pieces having the required colors, fitted together and held by leaden *cames.* See GLASS-STAINING.

Even with this distinction the subjects become somewhat involved as the processes have been combined.

The growth of the art has developed four modes: —

1. The *mosaic.* This is the earliest, and was known in Byzantium at an early date. It is not known that colored-glass windows were known in Rome, though white-glass windows are found at Herculaneum and Pompeii. The art is supposed to have been brought from Byzantium to Venice and Marseilles, and was practiced by the Saracens throughout the cities of the East.

Stained-glass windows were in the basilica of St. Sophia and other churches in Constantinople, in the sixth century; painted glass windows not till two or three centuries later, notably in the reign of Charlemagne. Some windows executed in the tenth to the twelfth centuries are yet in existence in Europe. The fifteenth century (*cinque cento*), under Albrecht Dürer and others, produced many beautiful specimens, some of which still remain; for instances, the Church of St. Jacques at Liege, and windows ornamented by the Crabeths at Gouda, in Holland.

2. The *mosaic stain.* In this mode the window is made up of detached pieces, as in the *mosaic;* but the shades are given by a stain of brown, which seems to have been the first color which the artists succeeded in *firing* on to the pieces of glass.

3. The *enamel.* By this all the required colors (see GLASS-COLORING) are painted upon the same piece of glass and fired in the kiln, producing the effect of an oil-painting. William of Marseilles (1475 – 1537) was a distinguished enameler on glass.

4. The *mosaic enamel.* In this mode *colored* glass is used as a groundwork to paint on, instead of *white.*

Glass-pa'per. The fragments of broken wine-bottles, etc., are carefully washed to remove dirt, the glass is crushed under a revolving stone and sifted into six sizes, as in manufacturing emery. It is sifted through sieves of wire-cloth, which are generally cylindrical, like the bolts of flour-mills. The cloths have from sixteen to ninety wires to the inch.

A surface of thin glue is spread on the paper, and the pulverized glass dusted over it with a sieve.

Sometimes two coats of glue and glass are applied. Under Edwards's patent (English), cotton cloth is used instead of paper.

Emery, sand, and powdered flint are used instead of glass, and constitute *emery, flint, sand* paper.

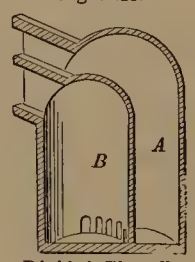
Glass-pot. The pot in which the *frit* is fused into glass. They are made of pure refractory clay, mixed with about one fifth its weight of old pots pulverized by grinding, are built up instead of being formed on a mold, and baked by being subjected to a white heat. Different forms are used for different kinds of glass. *a,* flint-glass pot. The horseshoe shaped piece is for contracting the opening. *b,* pots for colored glass. *c,* pot for crown-glass, with ladles. The pot in Fig. 2248 contains two or more compartments, *A B,* which communicate through openings at bottom.

Fig. 2247.

Glass-Pots.

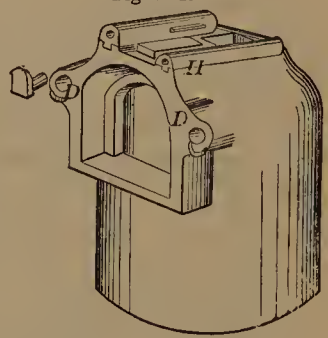
Newman's pot has two side flues *D D* for carrying off the heated gases, and two upper flues *H H* for supplying hot air to insure more speedy liquefaction of the charge.

Fig. 2248.



Divided Glass-Pot.

Fig. 2249.



Newman's Glass-Pot.

Glass-press. A device to apply pressure to glass in a mold while in a plastic state. In the press shown, the plunger is hung on a sliding head moving upon guides and operated by connection with a rock-shaft. The cover of the mold is held down by followers, and the mold slipped in and out at the requisite periods. Power is applied by a lever, which is counterpoised by a weight.

Glass-roll'ing. About 1849, Bessemer obtained a patent in England for a process of rolling glass, to make plate-glass and avoid the undulating surface incident to blown window-glass.

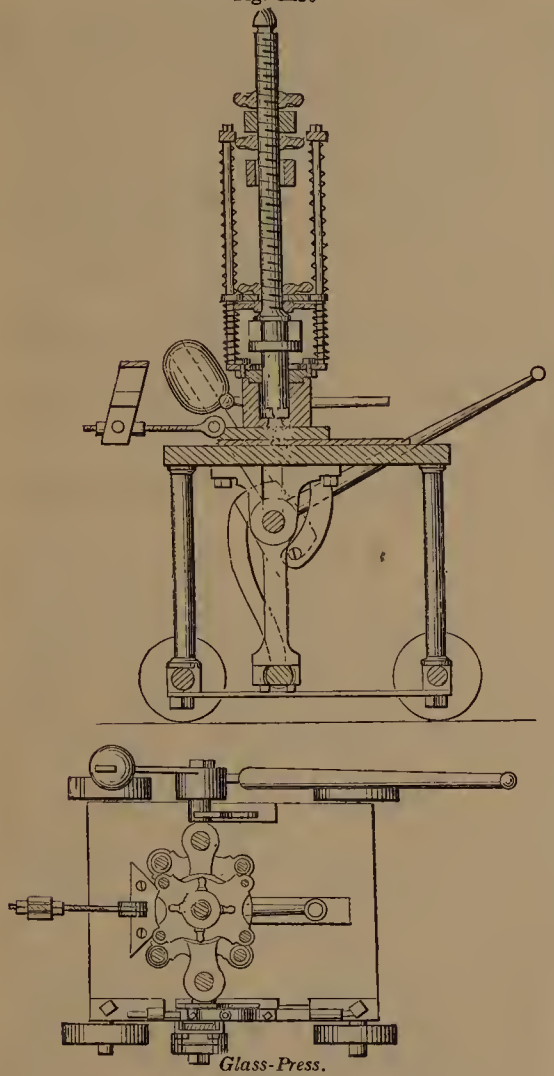
Messrs. Chance, of Birmingham, expended £100,000 in trying to perfect the machinery therefor, but failed to accomplish it, and abandoned the enterprise. The glass, in its pasty condition, was passed from a hopper between two rollers on horizontal axes and was received on a flattening-table.

Glass-sil'ver-ing. Glass for mirrors or ornamentation is silvered by one of two methods; the first is merely factitious: —

1. *The amalgam method.* A sheet of tin-foil is spread evenly on a smooth marble table; on this mercury is evenly spread with a hare's foot until the amalgam is produced. Mercury is then poured to a certain depth, — the English rule is, "as deep as the thickness of a crown-piece," — and the clear, dry sheet of glass slipped over the surface of the liquid metal, excluding all bubbles of air, or dirt, or floating dross. Pressure and standing in a slanting position to drip conclude the operation. See MIRROR; SILVERING; PLATINIZING.

For convex and concave surfaces, a mold of plas-

Fig. 2250.



Glass-Press.

ter is formed to fit the amalgamated foil to the surface.

Globes and hollow vessels are silvered by application of amalgam, such as lead, 1; tin, 1; bismuth, 1; melt; cool to lowest point they will remain liquid, and add mercury, 10. Stir with an iron rod.

Or, lead, 1; tin, 1; bismuth, 2; mercury, 4. Warm the vessel, pour in the amalgam, turn the vessel round and round, and, at a certain heat, the amalgam will be found to adhere to the glass.

2. *The humid way.* A mixture of nitrate of silver, 1, liquor ammonia, ½, water, 2, is settled and filtered, and to this is added alcohol, 3, and a few drops of oil of cassia. This is floated on the glass, being restrained by a wall of putty. Pour off, and varnish the metallic surface. Hollow vessels are silvered by pouring in the solution and turning them round and round. Other oils or grape-sugar are also used.

Vohl has a solution of gun-cotton in caustic potassa, to which is added a solution of nitrate of silver, followed by sufficient liquor of ammonia to redissolve the precipitate. The resulting argentiferous liquid is applied to the glass, which is heated over a water-bath until effervescence ensues, when the silver is deposited.

Cooley recommends: Mix saccharic acid with solution of nitrate of silver, decant, apply, precipitate by solution of ammonia, and heat to render deposit brilliant.

Glass-soap. Peroxide of manganese used to remove from glass the green color due to the presence of iron.

Glass-sol'der-ing. Guinand, of Brenetz in Neufchatel, acquired the art of soldering together pieces of glass. When the line of junction was marked by globules of air or particles of sand, he ground out the latter on the wheel, then replaced the mass in the furnace, so that the vitreous matter might expand and fill up the spaces. He thus combined good pieces of glass, so as to build up lenses of flint-glass of fine quality. Guinand joined Frauenhofer in Munich in 1805, and returned to his native canton in 1814, where he died, and was succeeded in his business by his sons.

Glass-spin'ning. Brumfaut of Vienna works a process in which he makes curled or frizzled yarn of glass. The composition is a secret. One workman with a wheel having a diameter of 5 Austrian yards will spin 3,500 yards per minute. It is used for many descriptions of fabric and for many purposes, cushions, carpets, table linen, shawls, neckties, etc.

Bonnet's European patents for cloth of glass are dated in 1837. The warp is of silk, the weft of glass spun by steam-engine power, about sixty threads to the inch.

Glass-stain'ing. *Stained-glass* is colored in the process of manufacture.

Painted-glass is a colored or white glass on which a metallic paint is laid, and subsequently fixed by fusing, — *fired in*, as it is termed.

Stained-glass windows are executed in pieces of colored glass, which are cut to the shape of the patches of color in the original design and are brought together in the manner of *mosaic*. These pieces are set in leaden frames called *cames*. This is the most ancient practice and is still in use.

The design is first sketched on paper, the colors and the exact arrangement of the pieces are then determined, so that it may be known just how many will be required, and their proper shapes and sizes. Some windows are composed of more than 10,000 pieces.

The material used is crown-glass made in large sheets expressly for the purpose. The greater portion of that used in this country is American, but some of the very fine colored glass, as ruby, blue, purple, and green, is imported.

The sheets are cut to their proper shape and size with a glazier's diamond, and then painted by laying on with a flat brush a thin, uniform coat of the proper color. These colors are all mineral, as they have to be long subjected to an intense heat in order that they may become firmly united to the substance of the glass.

Crown-glass is used as being less fusible than that containing a large proportion of lead. Being comparatively intractable, it does not fuse when the enamel colors melt and unite with it through the medium of the flux with which they are incorporated.

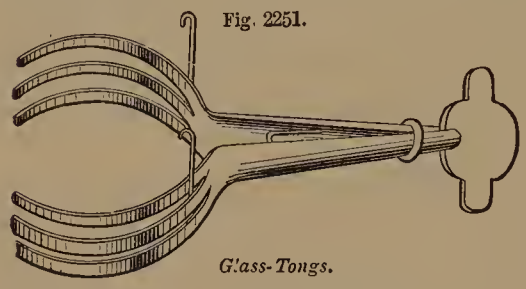
Reds and yellows are produced from silver and antimony; another red, from oxide of iron; white, from block-tin; black, from manganese; green, from copperas; and purple, from gold. See GLASS COLORING.

The colors are pulverized and mixed with a flux composed of red lead, flint-glass, and borax, which are melted together in crucibles. This composition made into a paint is laid on as previously described, and allowed to dry, when the sheets are transferred to the kiln, an oven of brick about 5 × 4 feet in dimensions, and provided with shelves made of iron plate on which the pieces of glass are piled twelve or fifteen deep, when the doors are closed,

and a heat sufficient to heat the glass red hot is maintained for eight hours, when the fires are drawn and the glass is allowed to slowly cool for forty-eight hours for the purpose of annealing it. By the fusion of the flux and partial surface fusion of the glass, the colored coating is thus inseparably united to the latter.

Glass-tongs. Grippers for hot bottles, etc., in

Fig. 2251.



Glass-Tongs.

course of manufacture, or for handling bottles containing heated or freezing mixtures.

Glave. A weapon formerly used, consisting of a curved blade on the end of a pole.

Glaze. A vitrifiable composition for covering earthenware or porcelain. Glaze on earthenware has several objects: —

1. To render the ware impermeable to liquids.
2. To impart luster.
3. To preserve colors and patterns.

It must adhere firmly to the ware, and expand and contract in the same proportions therewith, so as to avoid cracking and scaling.

It should resist acids, so as not to be dissolved by vinegar and other acid substances.

It should not have such an affinity for the ware as to sink into the latter when in a biscuit condition.

Glazes are of several kinds: —

Felspar is the base of a vitreous glaze which melts at a high temperature. It is found in natural combination with quartz; or is mixed therewith, sometimes with lime. It is principally used on porcelain or china.

A second class of glazes includes salt, potash, boracic acid, phosphate of lime, and sulphate of baryta; used on stoneware.

A third class is a glass, mainly consisting of silica and lead.

The fourth class includes the oxides of lead, tin, manganese, and copper.

Glazes are further subdivided into —

Transparent.

Opaque.

Colored.

Transparent glaze is a glass.

Opaque glaze is compounded with oxide of tin.

Colored glazes derive their peculiar tints from metallic oxides, manganese, copper, iron, cobalt, chromium, etc. See ENAMEL.

Glaze is applied in various ways: —

Some common earthenwares are glazed by throwing salt into the kiln at certain stages of the firing process. A partial vitrification of the surface takes place at the expense of the silica of the paste.

The salt is sublimed, producing a saline atmosphere throughout the kiln, the soda enters into combination with the silica of the ware, forming for the alumina, etc., a flux; and producing a glassy surface on the ware.

Porcelain and fine ware, while in the biscuit condition, are dipped into a thin solution of the glaze. The ware in this condition is very absorbent, and the water passes into the biscuit while the body of the glaze adheres to the surface.

In this case the glaze consists of vitreous matter fritted in a furnace and reduced to powder. The powder is stirred up in water and held suspended while the ware is dipped.

Articles only requiring an interior glaze receive it by pouring a quantity into them, swashing it around and pouring out the surplus.

Other ware is glazed by means of a brush.

Glazes are ground in water to a thin cream, forming a *slip*, in which clay-ware in the form of *biscuit* is dipped. The heat of the kiln fuses the *glaze*.

Glazes are white or colored, they differ only in that the latter have coloring ingredients.

For earthenware. *Lead glaze:* white lead, 53; quartz, or ground flints, 36; felspar, 16; white flint-glass, 5.

For chemical vessels. Fine sand, 48; potassa, 39; lime, 9; niter, 4. Oxide of tin or cobalt may be added to correct color.

For porcelain. Felspar, 27; borax, 18; fine sand, 4; niter, soda, and kaolin, 3; mix, frit, powder, and add calcined borax, 3.

For painted stoneware. White felspar, 26; soda, 6; niter, 2; borax, 1; frit. Of the product take 13; red lead, 50; white lead, 40; ground flint, 12.

M. Richard, ceramic manufacturer at Saint-Christophe, near Milan, has communicated to the Society of Encouragement, Paris, his process for varnishing pottery, and applied by him to different products exhibited at the Champ de Mars (Group III. Class XVII., Italian Section). The following are the ingredients and their proportion to be fritted: Carbonate of soda, 1.000; boracic acid, from Tuscany, 0.800; kaolin, 0.125; carbonate of lime, 0.250; sulphate of lime, 0.250; crystallized felspar, 0.750; quartz from the Tessin, 0.280; fluate of lime, 0.150. Manganese of Piedmont is added to obtain the desired tint. The whole frit is ground fine, and then mixed with 110 parts of kaolin and 52 parts of felspar for every 460 parts of the above frit. It is applied as usual in glazing, but, as the specific gravity is less than the leaden coating, the same weight of the new glaze will cover a greater quantity of pieces.

Vitreous glazes originated with the Chinese, and passed from them to India, and successively to Persia, Arabia, Spain, Italy, and Holland.

Previous to the introduction of glazes, the Greeks and Romans covered their pottery with wax, tallow, or bitumen. The Peruvians used tallow spread upon the ware while hot and thereby partially carbonized. The Etruscan ware has a similar appearance. In Italy and Spain, ancient and modern, wine-jars are rubbed with wax to render them impervious to liquids.

Among the early instances of glazing may be mentioned the tomb of Sultan Mohammed Khoda-Bendeh, at Sultanieh in Persia. He was the 12th prince of the house of Genghis Khan, and died in 1316. The tomb has green enameled tiles on the outside and blue on the inside.

The "painted mosque" of Gour in India, built in 1475, derives its name from the number of glazed tiles with which it is ornamented.

The Caravansérai of Mayar, near Ispahan, built by the mother of Shah Abbas, about 1550, has a covering of green glazed tiles on the front of the principal gateway.

The Alhambra, a Moorish palace and fortress near Granada, was founded by Mohammed I. of Granada about 1253. Some of the rooms are ornamented by glazed tiles.

Coffins of green glazed pottery are found at Warka in Mesopotamia, and are ascribed by Rawlinson to the period of the Parthian occupation of that country. This is a startling supposition. The style of

ornamentation and the figures stamped upon them forbid the supposition that they were imported from China, and yet this single fact of glazed pottery in that place at that time is almost irreconcilable with the observed contemporary progress of the art of making pottery in general. See Fig. 1377, p. 587.

Glazed Board. A kind of mill-board having a hard, smooth surface, to give a smooth face to the paper or fabric pressed between such boards.

Glaze-kiln. (*Pottery.*) A kiln in which glazed *biscuit*-ware is placed for firing. It is analogous to the *glost-oven.*

Glaz'er. 1. A cutler's or lapidary's wheel of a grade between the grinding and the polishing. It is made of disks of wood so arranged as to present the grain outwardly, that is, radially. The wooden surface is fed with emery-cake. Mahogany, oak, apple, beech, or birch, are employed.

Other *glazers* have a covering of leather or a cap of lead or tin alloy to carry the emery for grinding or glazing cutlery.

Lapping is done on metallic wheels.

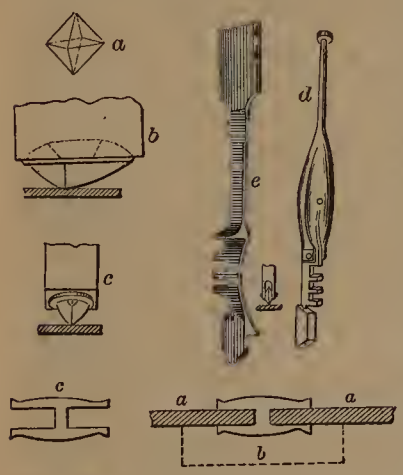
Polishing on leather-covered wheels.

Buffing on leather with rouge.

2. A calendering or calico-smoothing wheel.

Gla'zier's Di'a-mond. An implement for cutting glass consisting, as now universally made, of a handle, by which it is held between the fingers and guided, and having swiveled at its lower end a holder or block, in which a small diamond with one of its natural angles exposed is inserted. By this arrangement, invented by Joshua Shaw, the cutting edge of the diamond constantly tends to maintain its parallelism with the straight edge or pattern which guides it, so as to make a clean, smooth cut. The knack of using this tool properly, and judging of the proper vertical angle at which it should be held, requires some practice. The sound indicates whether or no a clean cut is being made. The normal crystalline form of the diamond is octohedral, and the faces are usually convex. Upon this latter peculiarity, according to Dr. Wollaston, its efficiency depends, the rounded edge slightly indenting the glass and then slightly separating its particles, forming a shallow fissure with a splitting rather than a cutting action, none of the material being removed. This fissure is readily extended through the glass, a slight degree of force serving to separate the two parts. He succeeded in producing the same result with several other hard gems by giving them the same form, but the natural edge of the diamond being so much harder and more durable, renders it much more economical than any other material for the purpose. *a* shows the primary crystalline form of the diamond, a regular octohedron. *b c*, diamonds with rounded faces forming a more or less acute angle. *d*, an improved form having teeth for breaking apart the two pieces after making the cut. *e*, an implement denominated the "universal glazing-tool," for cutting and setting glass. This has a small thin roller pivoted at its lower extremity, which in its passage over the glass separates the particles in a manner similar to the diamond.

Fig. 2252.



Glazier's Diamond and Vise.

The spatula at the other end is used for puttying, etc.

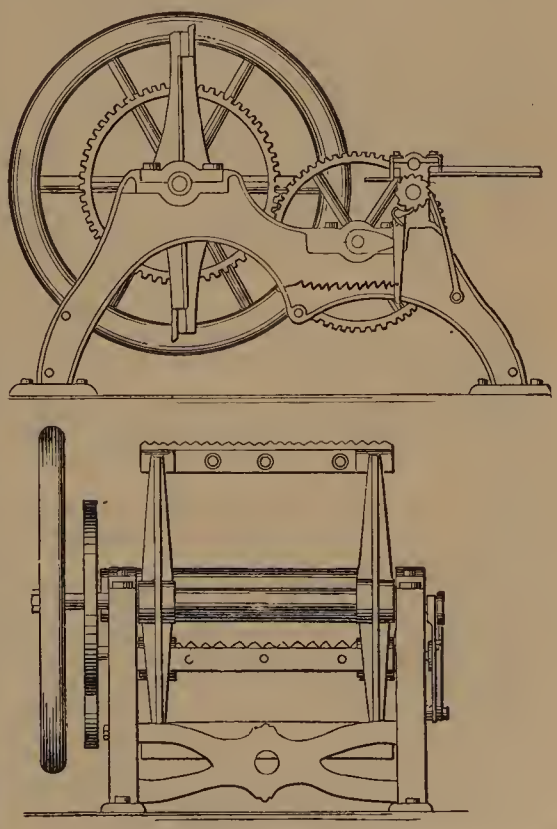
The diamond is crystallized carbon. Diamonds were first brought to Europe from the mine of Sumbalpoor. The Golconda mines were discovered in 1534. The mines of Brazil in 1728. Those in the Ural in 1829. The great Russian diamond weighs 193 carats; cost, £104,166 13 *s.* 4 *d.* in 1772. The Pitt diamond weighed 136 carats; sold to the king of France for £125,000, in 1720. The Koh-i-noor was found in 1550. It belonged in turn to Shah Jehan, Aurung-Zebe, Nadir Shah, the Afghans, Runjeet-Singh, and Queen Victoria, 1850. It originally weighed 800 carats, was cut down to 289 carats by an unskilful Italian, and then to 102¼ carats to perfect its shape. See Diamond.

Pliny speaks of *adamant* as the hardest of all materials, and it may mean the uncut diamond. We do not know that diamond-cutting was practiced, and it is not certain that diamond-dust was employed in gem cutting and engraving, although there are several indications of its use. He says: "Diamonds are eagerly sought by lapidaries, who set them in iron handles, for they have the power of penetrating anything, however hard it may be." He farther cites that all gems are engraved by the diamond.

A German authority states "they used, for the purpose of cutting sheet-glass, emery, sharp-pointed instruments of the hardest steel, and a red-hot iron by which they directed the rents at their pleasure."

An early notice of the use of the diamond in cutting, or rather scratching, glass is associated with a love-quarrel, in which Francis I. of France, 1520,

Fig 2253.



Glazier's Points Machine.

wrote with a diamond set in a ring, on a pane of glass in the castle of Chambord, a couple of lines to Anne, Duchess of Estampes. It seems to have been the subject of a patent to Gaspar Lehmann of Prague early in the seventeenth century, and granted by the Emperor Rodolph II.

Gla'zier's Knife. A knife used by glaziers in clearing out the remains of old panes from the fillisters of sash, and puttying in new ones. Such knives are known as *hacking*, *stopping*, and *putty* knives.

Gla'zier's Point. A small, triangular piece of tin plate, employed to secure a pane of glass in the sash previous to puttying. They are made in a machine in which the sheet of metal is fed to the rotary cutters, and the points are cut off in two or more rows at each rotation. The face of the cutter is notched like a saw-blade, and snips from the edge of the plate a row of triangular pieces.

Gla'zier's Vise. (*Plumbing.*) An apparatus for forming leaden bars for the reception of window-glass. The bar is called a *came*, and the mode of glazing is called *fret-work*. The came is formed by drawing a plain bar of lead between two rollers *a a* (Fig. 2252), of thickness equal to that of the glass, and having corrugated edges which draw the bar forward between two pieces *b b*, causing it to assume the shape *c*. The whole device constitutes the glazier's vise.

Glaz'ing. 1. Placing panes of glass in sashes.

2. Giving a vitreous coat to pottery.

3. Polishing metal on a wheel dusted with polishing-powder.

4. Spreading a semi-pellucid cover over a painting to soften asperities.

5. (*Gunpowder.*) All good powder is glazed in order to enable it to more perfectly resist moisture and bear transportation. For this purpose the grains from the breaking rollers, after having been assorted by sieving, and while still containing three or four per cent of water, are placed to the amount of several hundred pounds in a glazing-barrel; this is journaled at the ends, and is caused to rotate for some ten or twelve hours, breaking off the angular projections of the grains and causing them to assume a smooth and glossy surface.

Pulverized plumbago is sometimes added to produce a deceptive appearance of high glazing.

Glaz'ing-ma-chine'. A press with two polished rollers to calender paper.

Glaz'ing-wheel. A wooden wheel covered with leather charged with emery, and used by cutlers, especially for grinding and sharpening knives, tools, etc.

It is also used instead of filing for leveling and surfacing many metallic articles; for removing the scale from casting, and for trimming small castings, such as builders' hardware.

A wooden wheel without any leather covering is used by lapidaries in smoothing soft and rounded stones. These wheels are fed with flour, emery, and water.

Glass-cutters employ similar wheels with pumice-stone and water for smoothing, or putty-powder and water for polishing.

These wheels, commonly called *glazers*, are made of wooden disks or quadrants, so arranged as to present the end of the grain outwardly. They are fed with emery-cake; and by cutlers the wooden surface is frequently used without any leather covering.

Globe. A sphere on which is represented the heavenly bodies; a *celestial* globe. A round model of the world, representing the land and sea, and usually the political divisions. A *terrestrial* globe.

A celestial globe was taken from Egypt to Greece, 368 B. C.

A terrestrial globe is said to have been made in the time of Anaximander of Miletus, about 550 B. C. This is highly improbable. The determination of the latitude and longitude of places was of a later date, and is a necessary incident of a terrestrial globe.

The celestial globe of Billarus was taken away from Sinope by Lucullus (Strabo). The same writer mentions the sphere of Crates; Cicero that of Archimedes. Perhaps this was a planetarium.

The planisphere of Dendera in Egypt is a circular diagram of the zodiacal signs, and the most ancient and interesting of all representations of celestial scenery.

Gerbert, who studied astronomy among the Saracens in Spain, and was afterwards Pope Sylvester II., A. D. 1000, used in his school at Rheims a terrestrial globe brought from Cordova.

"While Rome was asserting, in all its absurdity, the flatness of the earth, the Spanish Moors were teaching geography in their common schools from globes. In Africa there was preserved, with almost religious reverence, in the library at Cairo, one of brass, reputed to have belonged to the great astronomer Ptolemy (about A. D. 130). Al Idrisi made one of silver for Roger II. of Sicily (A. D. 1131), and Gerbert used one he had brought from Cordova in the school he established at Rheims" (about A. D. 975). — Draper.

The globe of Gottorp is a concave sphere, 11 feet in diameter, with seats inside for spectators. Its concavity represents the constellations of the heavens, and its exterior is a terrestrial globe. It was constructed after the designs of Tycho Brahe, and turned on its axis. Dr. Long's globe was 18 feet in diameter, and held thirty persons, who viewed it while it was in motion. Mr. Wyld erected in Leicester Square a globe 60 feet 4 inches in diameter. Its concavity represents the terrestrial surface. It was lighted by openings during the day and by gas at night. Its interior was occupied by ladders and platforms, from which its painted surface was viewed. It was closed in 1861.

Martin Behaim on his "world apple," the celebrated globe which he finished in 1492, and which is still kept in the Behaim house in Nuremberg, places the coast of China (by estimate), only 100° west of the Azores. Marinus of Tyre had advanced the Chinese coast to the longitude of the Sandwich Islands, being misdirected by the calculations in the Asiatic itineraries, and thereby giving to the old continent a breadth of 225° instead of 129°. Ptolemy's geography estimated the Chinese coast at the longitude of the Carolinas. So Columbus started west on an uncertain expedition, and, believing Behaim, with whom he had been associated at Lisbon, 1480–84, concluded that in reaching land he had found Cathay. He caused the whole crews of his squadron (about eighty sailors) to swear that they *believed* he might go from Antilia (Cuba) to Spain by land, keeping west. Having letters from the Catholic monarchs to the Great Mogul Khan in Cathay, he sent on shore a baptized Jew who was acquainted with some of the Oriental languages, but his messenger failed to make connection. Columbus died before the error was discovered; he named the natives "Indians," and so much of the matter remains to this day. See Map; where the globes of Behaim and Schöner are compared with the previous maps of Ptolemy, Strabo, Hecatæus, and others.

"Then to Moxon's, and bought there a payre of globes; cost me £3 10*s*."— Pepys, 1663.

In the history of globe-making, the name of Ferguson, the mathematician, has an honorable place.

Modern globes are made of paper and plaster, are

perfectly balanced on their axes, and are proof against changes of temperature.

The first thing is a wooden mold, which is of a spherical form, and has two axial pins at its poles. This is placed in a frame, and, as it revolves, is covered over with wetted strips of strong paper. This is covered with successive thicknesses of pasted brown and white paper, laid in strips. The mold, with its paper covering, is then dried. Being dry, it is mounted in a frame on the axial pins, and the paper envelope is cut in two equatorially. The hemispheres are removed from the mold and are nailed to the ends of a central wooden rod, in whose ends are pins which project from each pole. The rod and pins form the axis. The hemispheres are joined at their edges by glue.

The shell is then placed on its axis in a frame and revolved as a compound of whiting, glue, and oil is plastered upon it. A semicircular scraper removes the redundancy and insures the spherical form. This coating is repeated four or five times, being dried between each coat. The sphere is then polished; then balanced by letting in shot in certain places to remove any want of equipoise.

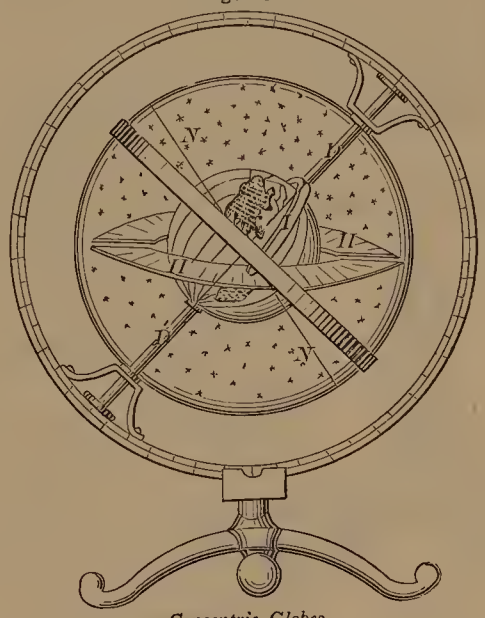
The parallels and meridians are now drawn on the globe by a beam-compass, to serve as guides for placing the engraved strips. These are fourteen distinct pieces. The arctic and antarctic circles are two circular pieces, and the other twelve are for the other portions, six on each side of the equator. The pieces of paper are thin, tough, and wet, and are rubbed down upon the globe, spreading them so as to make their edges exactly coincide with the lines on the globe. The globe is then colored according to geographical divisions, varnished and mounted.

A slate globe has lately been invented, having the meridians and parallels of latitude marked upon it, to be filled in by pupils as a geographical study. It is a powdered slate surface placed on the paper shell. A globe has been made in papier-maché, divided into forty-eight pieces, to be taken apart and put together at pleasure; the object being to facilitate package and removal, and the convenient study of any one part. Another novelty is a globe made of tissue-paper and inflated with air; such a globe may be made twelve feet in diameter, and is useful in a lecture or school room. A very cheap paper globe is now met with, in which the printed gores are brought together edge to edge by a string, not exactly to a spherical form, but sufficiently so for familiar reference.

Globes are also made by Goodyear, of inflated india-rubber, or of silk coated with india-rubber solution. Adams has made them of gutta-percha, with surface in relief, and in detachable zones and sections.

Globes of paper pulp have been suggested, molded inside of shells whose inner surfaces have intaglio representations of the inequalities of the earth's surface, so that the globe shall represent the mountains and valleys. It would be necessary to exaggerate the altitudes to make them visible. A model earth twenty-one feet diameter gives us only one thirty-second of an inch to a mile; on such a globe, one-hundred-acre farms would of course be utterly invisible to the naked eye, and the loftiest ranges of mountains might be represented by a few grains of rifle powder; and the entire human family, estimated at one thousand millions, might be gathered, without uncomfortable crowding, upon a spot less than one twelfth of a superficial inch. The greatest depths which man has yet been able to reach, in the way of mining or otherwise, would not exceed the thickness of thin card-board, and the entire animal portion of the earth now living would scarcely fill a child's thimble. The extent of the sensible atmosphere would not exceed one inch and a quarter; and if man shall ever be able to penetrate the earth to the depth of ten miles, it would be but little more than a quarter of an inch on this 21-feet

Fig. 2254.



Concentric Globes

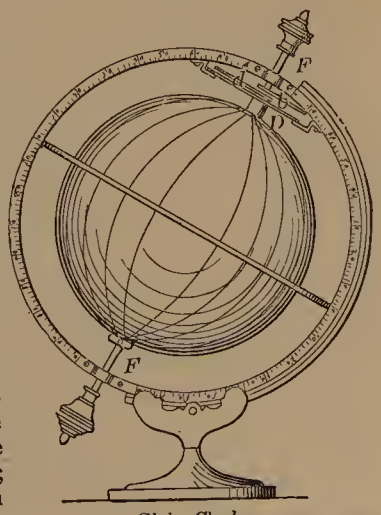
model; hence the model earth must be many times 21 feet in diameter in order to show to the naked eye any of the great works of mankind on a like scale.

Rigaud used the paper surface of a 36-inch globe to estimate the relative quantities of land and water. Carefully cutting the land and water apart with scissors, he weighed the two in a delicate balance, and found it, water 734, land 266.

Fig. 2254 represents a concentric arrangement of a terrestrial globe, and a transparent celestial globe with the constellations on the surface of two hollow hemispheres, which have also the line of the ecliptic *N*, and the solstitial and equinoctial colures. The universal horizon *H* is suspended from the forked arms *I* of the axis *D*. The line of the junction of the hemispheres marks the celestial equator. Ziebermayer's globe is of glass, with a glass shell marked with the constellations.

Globe-clock. A globe so mounted as to revolve once in twenty-four or twelve hours, as the case may be, so as to indicate the time on any meridian by an hour circle, or the noon at the time of observation by means of the meridian circle. In the example, the works of the chronometer are in the interior, and are wound up by the lower arbor *F*; these works turn the globe, the axis

Fig. 2255.



Globe-Clock.

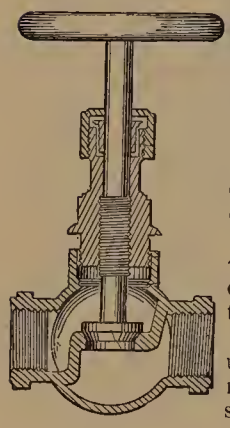
of the daily wheel of the chronometer being coincident with the axis *F*. *d* and *b* are hour and minute hands, which move around over the dial *D*.

Globe-cock. Formerly a sphere with a stem by which it was moved towards and from its seat; now a circular disk of similar use, and retaining the name, although but a zonal segment of a sphere is used. See GLOBE-VALVE.

Globe-fil'ter. A filter having a chamber of spherical form, whose hollow interior has a perforated diaphragm or a body of filtering material.

Globe-valve. 1. A ball-valve; one of a spherical shape, usually operated by a screw stem. The valve is now but seldom spherical, but is a disk or frustum of a cone fitting against a seat of corresponding shape, as in the figure.

Fig. 2256.



Globe-Valve.

2. A valve inclosed in a globular chamber.

Gloom; Gloom-stove. (*Gunpowder Manufacture.*) The drying-oven.

Glo'ry-hole. (*Glass-making.*) An opening in the wall, exposing the brilliant white of the interior of a glass-furnace.

Gloss'ing. An operation upon silk thread by which it is moistened with steam and stretched to develop a gloss.

Glos'so-co'mon. A form of winch with gear-wheels and pinions, and used for raising heavy weights.

Glost-ov'en. (*Porcelain.*) An oven in which glazed ware is fired.

Glove. 1. A covering for the hand (A. S. *glof;* Ger. *Handschuh*) differing from the mitten in having a separate compartment for each finger.

Gloves are made from a great variety of materials, as textile fabrics of cotton, linen, wool, silk, the pelts of the thinner-skinned animals, india-rubber, etc.; and in former ages steel, arranged in the form of plates or rings to afford flexibility, was employed for the gloves or gauntlets of the mailed warrior.

The skins principally employed for the finer kinds of gloves are those of the kid and goat, but other kinds of fine and flexible leather are also used. It has been asserted that large numbers of "kid" gloves were made from the skins of rats caught in the catacombs and sewers of Paris, but this assertion does not appear to be warranted by fact.

Great quantities of kid gloves are now made in this country, the process of manufacture, beginning with preparing the skins, being as follows.

In dressing kid or goat skins for gloves they are first soaked in water and "fleshed," and are then thrown into the vats of lime-liquor, where they remain from three to six weeks, being occasionally moved and turned until the hair is sufficiently loosened. They are then stretched upon the *beam*, and the hair removed with the blunt drawing-knife, carefully preserving the grain. They are next put into a *dreneh* of bran and water, or, more properly, moistened bran, where they remain for a considerable time. This softens and renders the skin very pliable. On being removed from this, the *tawing* process, which is a substitute for tanning with bark, takes place. The skins are covered by a mixture of salt and alum, which makes leather of them. After being cleansed and dried they are ready for the finishing processes. They are suspended and *staked*, that is, evened by a blunt knife drawn over the surface. Afterwards they are spread out upon a flat surface and rubbed with a sponge dipped in the beaten yolk of eggs. This preparation is absorbed by the leather and serves to make it elastic.

The next and last process is coloring. Liquid dyes are used for this purpose, and they are applied to the surface or grain of the leather with a brush. After all the processes of trimming, finishing, and dyeing are completed, the skin is stretched upon a marble table and rubbed with a blunt knife. It is then cut through the middle, and a strip for the palm and back of a glove cut, just wide enough for the purpose, from one end of each piece. Being cut in this way the pairs are alike, of similar finish, thickness, and tint. In some factories gloves are cut in part by punches of steel, which have teeth that prick the holes for the stitches. The seams are then sewed by laying the edges evenly together and placing them in a vise provided with teeth one twelfth of an inch apart, between which teeth the needle passes in sewing. After the seams are sewed the embroidery is put upon the back, the wrist bound or otherwise finished, and the fastenings sewed on. The glove is next stretched, placed in a linen cloth slightly dampened, and beaten to make it more flexible. It is then pressed, and is ready for the market.

By a slightly different mode of operation, after being assorted as to quality and size the skins are transferred to the cutter, who cuts them into oblong pieces of the required size, which are turned over to the puncher, who takes two or three pairs at a time and subjects them to the action of a press carrying a punch corresponding to the size of glove to be made, which forms the hand with all the necessary slits, openings, button-holes, gussets, etc. The thumbs and *fourchettes*, or pieces between the fingers, are punched separately. Any roughness of the edges is removed by the scissors. After undergoing final inspection to detect defective pieces they are sent out to the sewers, and on their return are "topped," the buttons sewed on, and button-holes completed.

They are then "dressed" or straightened, stamped with the maker's name, and packed.

In Europe the skins of the young kid, roughly dried in the open air, are collected by peddlers who, setting out from Italy in the early spring, extend their peregrinations to the northern confines of the continent as the season advances and the young kids attain a sufficient degree of maturity. By the peddlers the skins are sold to traders in the larger towns, whence they find their way to the great marts for such articles, as Naples and Leipsic.

The method of treating the skins is essentially the same as that adopted in this country. Some of the French manufacturers tan and dye the skins themselves, so as to insure uniformity in color and quality, while others are content to buy them ready prepared.

The dye is applied to the outer surface of the leather only by means of the hands and the assistance of a brush, and does not penetrate beyond the exterior. The best skins are colored black and other dark tints, holes or other imperfections showing more plainly in these than in lighter colors, so that the poorer kinds are used for white and other light shades. The variety of tints is about two hundred.

There are ten different sizes, from 5¼ to 8, for ladies' gloves; thirteen, from 7½ to 11, for gentlemen; and seven, from 5 to 6¼, for misses. Each of these sizes has a corresponding plate which serves as a guide to the cutter.

Buckskin or deerskin gloves also form an important article of manufacture. The skins are derived

from various parts of the North American continent, from South America, and a few from Europe and Asia. After being limed, fleshed, and unhaired, they are treated with oil in a stamping or pounding mill; the oil is removed by means of soda-ash, with which it forms a soap that is washed out. The skins are then stretched and suppled by rubbing with a stretcher iron or *stake*, colored with a wash of ocher, and their surfaces smoothed by grinding on a wheel covered with emery and pumice.

The gloves are cut out with steel dies, and stitched by a machine. When finished, they are dampened, stretched upon a hand-shaped board, dried and packed for transportation.

Fur gloves are made with the inner portion or palm of kid or dog skin, and the back of fur. They are lined with flannel or an inferior quality of fur, usually the white squirrel or coney or lamb-skin with the wool on, and are used in winter traveling, driving, etc.

India-rubber gloves are intended for the use of manufacturing chemists, druggists, and photographers, or all who work among acids, alkalies, and other caustic materials. They are also adapted to the use of firemen, hatters, tanners, and dyers.

In the manufacture of india-rubber gloves, the first process is to heat slightly a mass of the gum, which is rolled into a flat sheet between revolving cylinders. From this sheet the gloves and mittens are cut by gouges similar to those employed in the cutting of leather gloves. They are then joined by placing the edges in contact, and covering them with strips of heated rubber.

A lighter style is made thus: A piece of cotton cloth or stockinet is passed through the cylinders at the same time with the gum, which by this process completely coats it. From this the gloves are cut, and joined by covering the edges with strips of heated rubber. These gloves are made of a variety of colors, are very soft and pliable, and have a very neat finish. Gloves are made with corrugated rubber palms for use in washing.

Pliny recommends the use of gloves and boots to those engaged in pulling spartium, — a variety of the broom, and used, when soaked and broken like hemp, to make coarse cordage and the commonest description of garments. He also recommended them to his secretary, that he might not be impeded by chilly fingers in noting down memoranda.

Xenophon ridicules the effeminacy of the glove-wearing Persians. (*Cyrop.* VIII. 8, 17.) They do not appear to have been worn by the ancient Egyptians, but were regarded as a part of the indicative dress of Northern barbarians.

Some dirty-handed cynics calling themselves philosophers railed at the Roman gentry for wearing gloves.

The father of Ulysses wore gloves while working in his garden. So said Homer.

The use of gloves in common life is a habit of late introduction.

During the Middle Ages the glove was worn as a badge of distinction, and also in the helmet as a token of a lady's favor. See Hall's "Chronicle," time of Henry IV.

Charlemagne recognizes in a grant the use of leather in making gloves and book-covers. Ethelred II. had a present of two pairs from a merchant company. Henry II., when he lay in state, was habited in gloves. Elizabeth wore embroidered gloves, and is thus painted: —

"Painted leather gloves, very pretty and all the mode." — PEPYS, 1663.

2. (*Hat-making.*) A smooth piece of wood for rubbing a sheet of felt, and causing the nap to adhere to the body when working at the *battery*. The *glove* is held in the palm of the hand and tied on by a string.

Glove-mak'ing Ma-chine'. The apparatus upon which gloves are stitched consists essentially of a pair of jaws opened and closed by means of a treadle, and having at their holding edges teeth between which the needle is passed back and forth in sewing, thus regulating the length of stitch. The cutting apparatus has a reciprocating head provided with movable dies of various sizes.

Glue. Glue is made of the clippings of hides, horns, and hoofs; washed in lime-water, boiled, skimmed, strained, evaporated, cooled in molds, cut into slices, and dried upon nets.

It is principally prepared from the parings and waste pieces of skins, the refuse of tanneries, and the tendons and other offal of slaughter-houses. These are steeped in milk of lime for about two weeks and afterward dried. In this state they may be preserved for an indefinite length of time. Previous to boiling they are again steeped in weak milk of lime for from twenty-four to thirty hours, and then placed in a boiler having a perforated false bottom to prevent burning. (See GLUE-BOILER.) Here the scraps are gently boiled until a firm gelatinous liquid is produced, the clear portion of which is run off into another vessel, and a small quantity of dissolved alum added thereto. Here it is kept hot by means of a water-bath, and allowed to remain for several hours in order to deposit its impurities, after which it is run into the congealing boxes and placed in a cool situation.

On the next day the sheets thus formed are turned out upon wetted boards and cut into cakes, by means of a stretched brass wire, which cakes are farther subdivided by a moistened flat knife, and placed on nettings to dry.

They are, after drying, dipped into hot water and slightly rubbed with a brush wetted with boiling water to give them a gloss, and stove-dried. This furnishes the palest and best glue.

The residuum left in the boiler is treated with fresh water, producing an inferior article of glue, and this operation is repeated again and again, so long as any gelatinous matter can be extracted from the scraps.

Glue was used by the cabinet-makers of ancient Egypt.

The Greeks used various sticky matters, such as glue, bird-lime, and cobblers' wax.

"Wood is joined together with glue, prepared from certain parts of oxen, and with such strength that the veins of boards will open in a crack, sooner than the seams of ox-glue will relax their fastenings." — LUCRETIUS, Book VI.

Isinglass glue; soak isinglass in cold water; when swelled, put in spirits of wine; heat it in a bottle plunged in a bath; add powdered chalk.

Gelatine glue; swell in cold water; immerse in linseed-oil and heat in a bath; add red lead.

Water-proof glue; boil two ounces of isinglass in a pint of skim-milk, until the required consistence is obtained.

Marine glue; shellac and caoutchouc, equal parts, dissolved in separate portions of naphtha, and then mixed.

Or, india-rubber, 1 pound; coal naphtha, 4 gallons; shellac, 2 ounces.

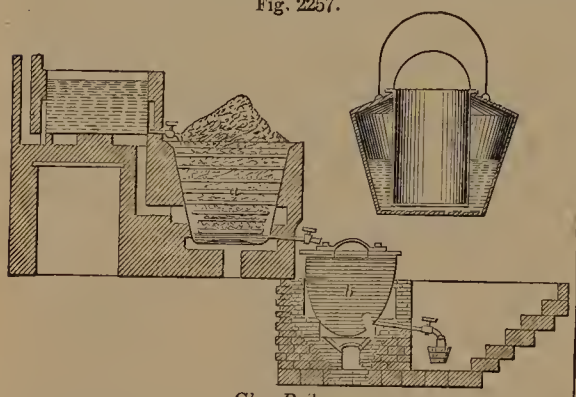
White fish-glue, or *diamond cement*, is made of isinglass dissolved in alcohol.

Spalding's liquid glue; glue and acetic acid.

Glue-boil'er. A convenient apparatus for boil-

ing skins into glue has three coppers, at different hights; the upper, acted on by the waste heat from the chimney, warms the water, which is then drawn off into the central one (*a*) in which the scraps are placed, and which has a perforated false bottom, and the third (*b*) receives the gelatinous solution

Fig. 2257.



Glue-Boiler.

obtained by boiling. The last vessel is double, with water between the inner and outer shells, and discharges its contents into buckets, by which the solution is transferred to the evaporating-boxes.

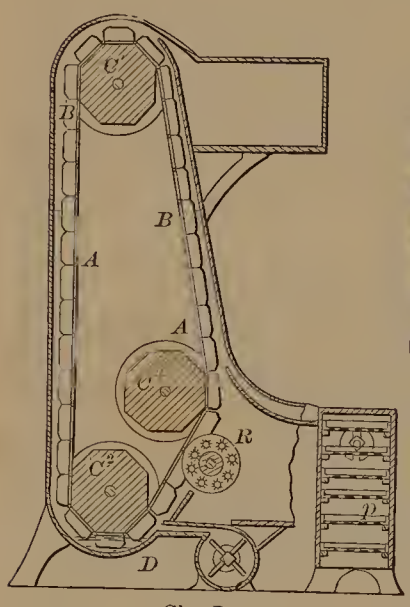
Above is shown a carpenter's glue-pot.

Glue-can. A kind of glue-pot in which the prepared glue is kept in the inner can, and it is surrounded by an outer tin vessel containing water for heating the glue.

Glue-ce-ment'. To resist moisture. Glue, 4 parts; black rosin, 4 parts; red ochre, 1 part. Or, glue, 4 parts; boiled oil, 1 part; oxide of iron, 1 part.

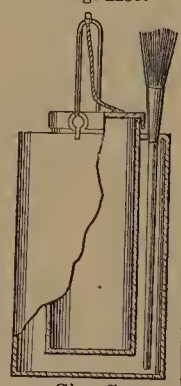
Glue-dry'er. A machine or closet for drying

Fig. 2258.



Glue-Dryer.

Fig. 2259.

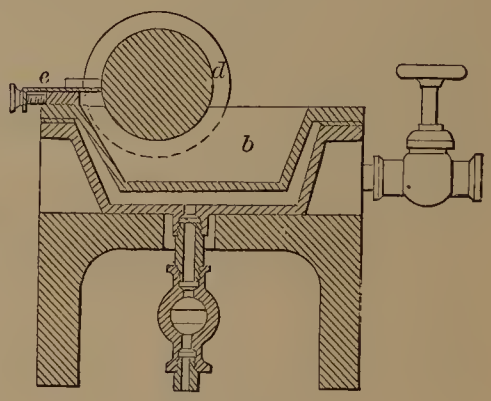


Glue-Can.

sheets of glue. In the example, the endless web *A B* has sections of plates which dip at their lowest position into the depression *D*, which contains liquid glue. As the octagonal roller C^1 C^2 rotates, the glue-covered plates ascend, being accompanied by a blast of heated and dry air from the blower below. An additional or intermediate pulley or drum C^3 is arranged between the two supporting pulleys, to deflect the endless chain and its plates against rotating disks carrying brushes *R*, which latter remove the glue from the plates. During their descending motion, the plates are exposed to air chemically dried in the furnace *p*.

Glue'ing-ma-chine'. One for smearing upon an applied surface a thin and even coating of liquid glue. In the example, *b* is a tank of glue kept

Fig. 2260.

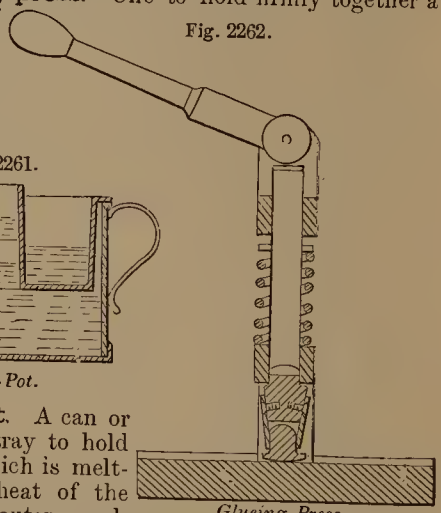


Glueing-Machine.

heated by a steam-jacket. *d* is a roller, whose lower portion revolves in the tank; a scraper *e* removes the redundancy, and its upper surface is coated with a thin pellicle, suitable for application to a leather strip which is to be joined to its fellow, or a veneer which is to be attached to an object.

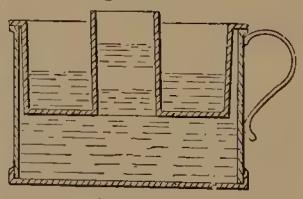
Glue'ing-press. One to hold firmly together a number of parts which have been attached by glue or cement.

Fig. 2262.



Glueing-Press.

Fig 2261.



Glue-Pot.

Glue-pot. A can or pot with a tray to hold the glue, which is melted by the heat of the water in the outer vessel.

Glut. 1. A wooden wedge used as a quoin, a chock in splitting timber, or as a fulcrum to a lever.

2. (*Nautical.*) *a*. A patch at the center of the head of a sail, having an eyelet for the becket-rope.

b. A choking, as by throwing the fall of a rope across the sheaves.

3. (*Bricklaying.*) A small brick or block introduced into a course to complete it.

Glyc'er-ine. A viscid, colorless liquid, having a sweetish taste but no odor, which may be derived from nearly all oily or fatty substances. It was discovered by Scheele in 1779. Its chemical combination is $C_6 H_8 O_6$. It unites readily with water, and the combination thus formed, as well as pure glycerine, is capable of solving a great variety of substances. Upon this circumstance, its non-liability to freeze at low temperatures, its slight volatility at temperatures below 200° F., and its efficacy as a preservative agent, its value in the arts chiefly depends. Glycerine is obtained by various processes, the object being to detach it from its combination

with the acids, oleic, margaric, and stearic, to which it is united as a base. The refuse from soap-making contains a large proportion of it, which has been usually thrown away.

It may be obtained by treating olive-oil with oxide of lead, leaving a residuum of impure glycerine, which may be purified by sulphuretted hydrogen, and concentrated by evaporation over a water-bath.

The preferable process is by passing steam, heated to between 500 – 600° Fah., through a fatty substance in a still. The glycerine and fatty acids distill over, are separately condensed, and may be concentrated by evaporation. The purity depends upon that of the substance employed.

Glycerine is employed in medicine as a vehicle for liniments, carbolic acid, etc., and may be used for forming extracts and tinctures. It is also employed in soaps and cosmetics of various kinds, imparting a sense of moisture and coolness to the surfaces where applied; and for preserving animal and vegetable preparations, not shrinking them as alcohol does. Its non-evaporability makes it useful as an ingredient in copying-ink, and by treatment with nitric acid it forms the well-known explosive nitro-glycerine.

Glyph. (*Architecture.*) Perpendicular fluting, used in the Doric frieze.

Glyph'o-graph. A name given by Mr. Palmer to his system of relief line-engraving.

A thin ground of wax is spread upon the plate; this is etched or cut away so as to give the design in intaglio. The ground is now covered with a film of graphite, after which metal is precipitated upon the metal in an electro-bath, giving a metallic plate with the design in relief. The copper shell is backed with lead and used as an ordinary printing surface. By a similar process the engravings which illustrate this book have been made. See RELIEF LINE-ENGRAVING.

Glyp'to-graph. An engraving on a gem or a semi-precious stone.

Gno'mon. 1. *a.* The style, or pin, which, by its shadow on the dial-plate, shows the hour of the day. See DIAL.

b. A rod or pillar, from whose shadow the altitude of the sun may be determined. Such were in use in ancient Egypt, in China, and such were found at Quito by the invading Spaniards.

The astronomer Uleg Beg erected a *gnomon* at Samarcand in 1437, the hight of which was 176.89 feet. The gnomon of the sun-dial of Delhi takes the form of an elevated staircase. See DIAL.

The *gnomon* or *style* of a horizontal dial has an edge parallel to the axis of the earth, and makes with the horizontal plane of the dial-plate an angle equal to the latitude of the place.

The gnomon was anciently used in China for astronomical purposes, but this people did not excel in dialing. A measurement of the length of the solstitial shadow, made by Tschen-Kung, at Loyang, on the Yellow River, 1200 B. C., was found by Laplace (quoted by Humboldt in "Cosmos," Vol. II. p. 115) to accord perfectly with the present accepted theory of the change in the obliquity of the ecliptic.

"The sun-dial and the gnomon, with the division of the day into twelve parts, were received by the Greeks from the Babylonians." — HERODOTUS, II. 109.

Eubulus, the comic poet, quoted by Athenæus, who wrote about A. D. 220, says: —

> "We have invited two unequalled men,
> Philo-crates and eke Philocrates, —
> For that one man I always count as two,
> I don't know that I might not e'en say three.
> They say that once when he was asked to dinner,
> To come when first the dial gave a shade
> Of twenty feet, he with the lark uprose,
> Measuring the shadow of the morning sun,
> Which gave a shade of twenty feet and two.
> Off to his host he went, and pardon begged
> For having been detained by business;
> A man who came at daybreak to his dinner!"

The gnomons of Peru disgusted the invading Spanish, who, of course, had never bowed to images. One obelisk at Quito was in the center of a circle, on which was marked an east and west line indicating the equinox. The ruthless conquerors thought it was an idol, and did not comprehend that they were on the equator. The men who were expelled from Cordova about 290 years previous could have explained the use of the pillar. See DIAL.

2. An instrument, more employed formerly than now, for measuring altitudes and declinations of the sun and stars. It was usually a column erected upon level ground or pavement. An observation made at Marseilles by Pytheas in the time of Alexander the Great showed that the gnomon at that place was as the meridian shadow at the summer solstice, as 213½ to 600.

Cassini's celebrated gnomon in the Church of St. Petronius at Bologna was eighty-three French feet in hight.

Goaf. (*Mining.*) An excavated space from which the ore has been removed. It is sometimes made the receptacle for the *deads* and *attle* of the mine to avoid sending them up to the surface, and to support the roofs of the workings.

Gob; Gobb. (*Mining.*) *a.* A *goaf* or abandoned working in a mine from which the ore or coal has been taken, and is now used to contain refuse.

b. Attle, waste, rubbish of working. *Gobbing.*

Gob'e-lins. (*Fabric.*) A superior kind of French tapestry, deriving its name from the brothers Gobelin, the first manufacturers.

Go-cart. A small frame, without a bottom and running on casters, for teaching infants to walk.

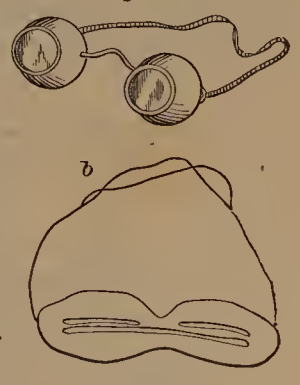
Gof'fer-ing-ma-chine'. A machine for making plaits or ruffles. See GAUFFERING-MACHINE.

Gog'gles. 1. Eye-blinds for horses.

2. Tubes or glazed cases in front of the eyes for protection from dust or intense light.

A similar arrangement for weak eyes was used by Pepys, and described by him in his "Diary" of April 25, 1669, under the name of a vizard "with tubes and glasses got to put in and out. I paid him 15 *s.*"

Fig. 2263.



Goggles.

Wooden goggles (*b*) are worn by the Yukon Indians of Alaska. They are used to diminish the light and prevent the glare from producing blindness. This mode of contracting the diaphragm resembles, except in not being automatic, the device in the eye of a cat, the iris of this animal diminishing by lateral contraction instead of orbital. See IRIS-DIAPHRAGM.

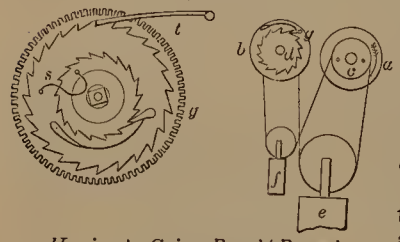
Go'ing-bar'rel. (*Horology.*) *a.* A barrel containing a mainspring and having a cog-wheel on its periphery which drives the train. It supersedes the arrangement of chain and fusee.

b. A ratchet-wheel with pawl and spring on the shaft of the great wheel, by which the works are

kept going while the clock is being wound up. Invented by the celebrated English watchmaker, Harrison.

In this, the larger ratchet-wheel, to which the click *t* is attached, is connected to the great wheel *g* by a spring *s*. While the clock is going, the weight acts upon the great wheel *g* through the spring; but as soon as the weight is taken off by winding, the click *t*, whose pivot is set in the frame, prevents the larger ratchet from falling back, and so the spring *s* still drives the clock-wheel during the time the clock takes to wind.

Fig 2264.



Harrison's Going-Barrel (Brown's Mechanical Movements).

A modification of the device was adapted by the same inventor to suit watches.

Go'ing-wheel. An arrangement invented by Huyghens to keep a clock in motion while winding. In Fig. 2264, *a* is the going and *b* the striking wheel, carrying on their axes the pulleys *c d*, which, by means of an endless cord or chain, sustain the pulleys carrying the weights *e f*, the latter serving merely to keep the chain taut; each of the pulleys *c d* supports half the larger weight, so that on turning the pulley *d*, in the act of winding, the weight *e* while being raised still continues to act with half its force on the pulley *c*, the pulley *d* turning so as to lift the weight *e*, and being prevented from going back by the engagement of the pawl *g* with its toothed exterior.

Gold. Equivalent, 98.7; symbol, Au. (Aurum); specific gravity, 19.2; point of fusion, 2282° F. Found in the native state, mechanically associated with earths and sometimes alloyed with metals. It is a heavy, yellow, lustrous, malleable, ductile, non-oxidizable, soft metal. Its uses are for coin, plate, ornaments, and articles of luxury.

Its principal sources are California, Australia, the western coast of Africa, and the Ural. It is a very widely disseminated metal, but is only found in paying quantities in a few countries. Wicklow, in Ireland, parts of Nova Scotia and of Virginia and North Carolina, yield this metal.

The principal supplies of gold in the land of Egypt were derived from the gold mines in the desert of the Upper Country. Their position, according to Wilkinson, is still known to the Arabs, and is about southeast from Baháyreh, a village opposite the town of Edfou, at a distance of ten days' journey. The gold lies in veins of quartz in the rocks bordering an inhospitable valley and its adjacent ravines, and yields a small quantity in proportion to the labor required. Water is scarce, the locality is remote from food and the materials necessary for the prosecution of the work, and do not seem to offer any prospect of reward for reopening.

They were run by slave power at a time when the sacrifice of human life by hardship was a matter of little concern; as was evinced in other regal undertakings, — the building of the Pyramids, the quarrying, moving, and erection of the monoliths, and the digging of the canal from the Nile to the Red Sea.

Agatharcides states that the toil of extracting the gold of these mines was immense. The rock was pounded fine, and the gold was separated by frequent washings, and the account is confirmed by paintings on the tombs executed in the reign of Osirtasen, about 1740 B. C.

Mehemet Ali announced his intention to reopen these mines, but desisted. He was tyrant enough for the purpose, but had a method in his madness, and was doubtless deterred by mechanical and climatic difficulties. The skeletons of the victims of his rapacity in Egypt would have paved the road across the desert to the desolate hills devoted to the *auri sacra fames*.

These mines are said to have yielded $35,000,000 per annum in the times of Rameses II., fourteenth century B. C., and were still worked under the Ptolemies.

The "*molten* calf" and the fact that Aaron "fashioned it with a graving tool" show that casting and engraving metals were known 1490 B. C., and the character of the articles found in the tombs, as well as the paintings and sculptures, point in the same direction. A curious series of pictures at Beni-Hassan point out with some clearness the process of collecting and working gold. (Fig. 2265.)

Reference has just been made to the account of Agatharcides, where he describes the hardships of the gold-miners. A fuller description is given of it by Diodorus, entering into a detailed statement of the cruel treatment of the unfortunate convicts who were sent by thousands to the spot and worked under the lash without any alleviation, care during sickness, or any hope except in death. The account

Fig. 2265.

Gold Operations in Egypt, 1700 B. C.

is too long to insert, but stands along with the history of Spanish operations in the gold mines of Hispaniola as an example of what can be done by men who "neither fear God nor regard man."

The illustration is taken from a tomb at Beni-Hassan, and includes the operations from the washing of the pounded ore to the making of jewelry.

The words of Diodorus, 10 B. C., throw much light on the process employed in his time. He states that the "marble shining rock" (quartz) is excavated by main force by iron picks and chisels, and carried by boys from the bottom of the shafts to the open air. It is then pounded by iron pestles in stone mortars till the pieces are reduced to the size of a lentil. It is then ground in the ordinary hand mill to a fine powder. He then proceeds to say: "At length the masters take the stone thus ground to powder and carry it away to undergo the final process. They spread it upon a broad table a little inclined, and, pouring water upon it, rub the pulverized stone until all the earthy matter is separated, which, flowing away with the water, leaves the heavier particles behind on the board. This operation is often repeated, the stone being rubbed lightly with the hand; they then draw up the useless and earthy substances with fine sponges, gently applied, until the gold comes out quite pure. Other workmen then take it away by weight and measure, and putting it with a fixed proportion of lead, salt, a little tin, and barley bran, into earthen crucibles well closed with clay, leave it in a furnace for five successive days and nights, when it is suffered to cool. The crucibles are then opened, and nothing is found in them but the pure gold, a little diminished in quantity. Such is the method of extracting gold on the confines of Egypt, the result of so many and such great toils. Nature indeed, I think, teaches that as gold is obtained with immense labor, so it is kept with difficulty, creating great anxiety, and attended in its use both with pleasure and grief."

The series of operations shown in the cut evidently refer to something similar to the process described by Diodorus. A man is spreading the auriferous mud on a board; then appears a man with a shovel, and another with an inclined chute. A fourth is working with a pan, into which water is poured by a fifth person. The latter also throws water into a riffle, which is a series of steps. Others are washing and stirring the material in pans. Next we see the scribe and the scales. Then the crucible, presided over by a man with a blow-pipe; and as a sequence are jewelers making up the gold into an ornamental form, for some purpose not apparent to the writer, though no doubt clear enough to the artist of thirty-five centuries ago.

Gold was first coined in England in A. D. 1257. The amount of gold that passed through the English mint from 1558 (accession of Queen Elizabeth) to January 1, 1840, is 3,553,561 pounds' weight, troy. The value of gold coined in the reign of George III. was £74,501,586.

An ounce of gold will cover a silver wire 1300 miles in length, and a grain of gold may be extended into a leaf of 56 square inches. Gold-leaf may be reduced to the 290,000th part of an inch. See AMALGAMATOR; GOLD-LEAF.

Gold-al-loys'. Those in which other metals are added to gold to confer hardness, as in coin, or to cheapen the product, as in some jewelers' alloys and solders. See ALLOYS, pp. 62, 63.

Gold-beat'er's Ham'mer. A hammer with two somewhat rounded faces, used in beating the pack of alternate gold ribbon and vellum or gold-leaf and skin. As the work progresses smaller hammers are used.

The *forging-hammer* is used in reducing the ingot of gold to one sixth of an inch thickness. The anvil is a steel block 4 × 3 inches on the face.

The hammer for the first course of beating is short handled and weighs 15 or 16 pounds. The hammer for the next beating weighs 10 pounds.

The French series of hammers is:—

The *flat* or *enlarging hammer*. Its head is slightly convex, and has a diameter of 5 inches. Its shape is a truncated hexagonal pyramid, the face being the base. It weighs 14 or 15 pounds.

The *commencing-hammer* is more convex than the flat, has a face of 4 inches, and weighs 6 or 7 pounds.

The *spreading-hammer* (*marteau à chasser*) is still more convex, has a head 2 inches in diameter, and weighs 4 or 5 pounds.

The *finishing-hammer* is still more convex, has a face 4 inches in diameter, and weighs 12 or 13 pounds.

Gold was beaten into thin sheets by the ancient Egyptians, and used in ornamenting furniture, coffins, and numerous other articles.

Gold-beat'er's Skin. Prepared from the peritoneal membrane of the cæcum of the ox. Used to separate the leaves of gold while under the hammer.

Gold-beat'ing. See GOLD-LEAF.

Gold-block'ing. Pressure of an engraved or composed block upon gold-leaf spread upon a book-cover. Without the leaf it is called *blind-blocking*.

Gold, Chlo'ri-na'tion of. See CHLORINATION.

Gold-fur'nace. This resembles a brass-furnace (see BRASS-FURNACE), but is usually built above the floor, occupying one side or more of the shop, and appearing like a stunted wall. The aperture for the fuel and crucible in each furnace is 9 to 16 inches square, and 11 to 20 inches deep. The front edge of the wall is horizontal and stands about thirty inches from the floor, but the top inclines backward at an angle of about 30°, and a ledge holds the *tiles* which close the tops of the furnaces.

The crucibles are usually of black-lead.

The auriferous copper ore of Colorado is thus reduced. The pyrites are roasted in kilns, wood being the fuel, expelling about half the sulphur. The black mass, protosulphide of iron, is calcined in brick ovens, being stirred with iron rods. The resulting black or brown powder is placed on the hearth of a reverberatory smelting-furnace, with such mixture of auriferous, argentiferous, and cupriferous ores as shall produce the reactions which will separate the materials into a floating dross and a pool of metal. The ferruginous slag is drawn off at an upper hole, and a mixture of gold, silver, copper, and iron at a lower hole, forming a *matt* which is shipped to Swansea, Wales, for complete separation.

Gold, Im-i-ta'tion. *Mock-gold.* See JEWELER'S ALLOYS, p. 63.

Gold-leaf. Gold-leaf was made in Egypt 1706 B. C. Homer refers to it. The temple of Solomon was profusely gilt. Pliny states that in his time a single ounce admitted of being beaten out into 750 leaves, four fingers in length by the same in breadth. This tenuity is very far exceeded at the present day. In the practice of the art in Europe, the skin of an unborn calf was first used; afterwards a fine pellicle from the entrails of cattle. This continues to be used (see *supra*). "About 1621," says Beckmann, "Merunne excited general astonishment, when he showed that the Parisian gold-beaters could beat an ounce of gold into 1,600 leaves, which together covered a surface of 105 square feet. But in 1711, when the pellicles discovered by the Germans came to be used in Paris, Réumer

found that an ounce of gold, in the form of a cube, 5¼ lines at most in length, breadth, and thickness, and which covered a surface of about twenty-seven square lines, could be so extended by the gold-beaters as to cover a surface of more than 1466½ square feet."

The Egyptian mummy-cases were sometimes profusely gilded, and in some instances the body itself.

A small percentage of silver and copper is added to gold for beating, perhaps about 1¼ per cent of alloy. The ingot is rolled into a *ribbon* by repeated passage between rollers, and this ribbon has a thickness of $\frac{1}{800}$, a surface of 500 square inches to an ounce of gold.

The gold-beater takes 800 pieces of the "skin," which is a tough, thin membrane from the intestines of an ox, and thus proceeds: A hundred and fifty bits of ribbon gold an inch square are interleaved with as many vellum leaves four inches square, forming a *cutch;* this pack is beaten for a long time with a ponderous hammer on a smooth marble slab until the gold has thinned and expanded to the size of the vellum. How the workman manages so as to beat all the pieces equally, and yet beat none into holes, he alone can answer; it is one of the mysteries of his craft. The gold is liberated from its vellum prison, and each piece cut into four; the hundred and fifty have thus become six hundred, and these are interleaved with six hundred pieces of gold-beater's skin, forming a pack called a *shodcr*.

Another beating then takes place, more careful, more delicate, more precise than the former, until the gold, expanded as far as its envelope will admit, requires to be again released. The leaves are again divided into four, by which the six hundred become twenty-four hundred; these are divided into three parcels of eight hundred each, and known as *molds;* each parcel is subjected to a third beating. Heavy as the hammers are, there are yet degrees of heaviness; first, a 16-pounder for the *cutches*, then one from nine to twelve pounds for the *shoders*, and lastly a hammer of from six to seven pounds is employed.

Gold-min'ing. The different modes of collecting gold in the placers of California — and the same is true of some other places, Australia, for instance — are familiarly known as *panning, winnowing, cradle-rocking*, washing with the *long-tom* or the *quicksilvcr-machine, jamming* or turning the course of a river, *burrowing* or *tunncling, ground-sluicing, sluiceboxcs* in connection with the *hydraulic proccss*, or water-jet. See list under METALLURGY; MINING.

In *panning*, the operator takes his station by the edge of the water, dips his pan, which he holds by the rim, and then imparts to it a rotary and oscillatory motion, occasionally stirring up the earth and mashing the clods. The large stones are thrown out and the water caused to circulate around the inside circumferencc of the pan, the heavier portions, including the gold, collecting in the center, and the lighter matters being discharged over the edge. The residue, consisting of fine gold and black sand, is separated after being dried.

The *winnowing* operation is practiced where water is not available, and consists of tossing in a blanket the finely powdered and dry earth, depending upon the wind to blow away the lighter particles.

The *cradlc* is a box about 3½ feet long, 20 inches wide, and 18 inches deep. The top and one end are open. Upon the rear half of the top is fitted a box with a perforated sheet-iron bottom. This box receives the earth, which is disintegrated therein, and passes through the holes as the cradle is rocked to and fro. Water is bailed by hand from the stream, and the gold is arrested in its passage by wooden cleats placed on the inclined bottom of the cradle, while the lighter matters are carried out at the end by the stream of water. See CRADLE.

The *long-tom* consists of a shallow, inclined trough, from 10 to 20 feet long and perhaps 16 inches wide. At the lower end is an upwardly inclined perforated plate to arrest the gold which falls through the holes into a box below, while the tailings pass over the end by the force of the stream of water which is introduced into the upper end of the trough. The gold is collected by *riffles* in the box, and quicksilver is added to amalgamate the finer particles, if necessary.

The *quicksilver-machine* is somewhat similar to that last mentioned, but is intended to bring all the gold in contact with mercury, the amalgam being afterwards treated for the removal of the mercury. See AMALGAMATOR.

In *jamming*, the water of a river is turned into a temporary chanuel while the bed is explored for gold.

Burrowing or *tunneling* are adopted as a more economical means of reaching the lower strata or more valuable deposit upon the hard pan, or ancient river bottom, instead of digging away or working over the whole mass of superincumbent earth.

Ground-sluicing consists in turning a stream upon a bank of earth to remove it and uncover the more valuable strata below, the auriferous deposit in the upper portion being detained by its gravity to be washed with the lower denuded layer of *pay dirt.*

Hydraulic-mining by jet and sluice-boxes has given rise to some of the greatest engineering works of California. A series of boxes about 14 inches in length and 3 feet wide, called *sluice-boxes*, are fitted together at the ends so as to form a continuous trough, as long as may be desired, sometimes extending several thousand feet. The earth and stones are washed through this sluice by the force of a strong current of water, often brought from a great distance. The sluice has a flooring of wooden blocks which offer some impediment to the passage of the earth, and afford crannies for collecting the gold, and for holding the quicksilver by which the finer particles of gold are arrested and amalgamated. The bank of auriferous earth is washed into the sluice, thus prepared, by means of a powerful stream conducted through and directed by a pipe in the manner of a fire-engine. The water is brought to the scene of operations from immense distances, in some cases over one hundred miles, and the flumes and canals which form a network over the country are among the most remarkable local features (see FLUME). To quote from the description of "A Miner of 1849," Harper's Magazine, April, 1860: —

"To shovel a mass of several millions of tons of earth into this sluice for washing would be too expensive. By means of water directed through hose and pipe the labor of many men is cheaply performed, and the hill torn down to its base. The water is led through india-rubber or double canvas hose, and generally from a great hight above the scene of operations. It is consequently thrown with such force as to eat into the hillside as if the latter were sugar or salt. Several of these streams directed upon a hillside bring down more earth than could be thrown by one hundred men with picks and shovels. But the art of the miner does not rest here. He undermines as well as breaks down, working in a single cavern in the hillside with his water batteries until the earth topples over like an avalanche." See HYDRAULIC-NOZZLE.

By a combination of shovels and the current of

water the earth is then carried into the sluice in which it is disintegrated and washed down with great rapidity, the gold catching, as has been observed, in the interstices between the blocks which form the floor of the sluice. See AMALGAMATOR.

Gold-pen. A pen with a gold *nib* pointed with rhodium or iridium.

In 1823, Hawkins and Mordan (English) made tortoise-shell and horn nibs with diamond and ruby points. These were followed by plates of gold attached to the tortoise-shell nibs.

Doughty's pens were of gold with ruby points.

Wollaston's pens were of two flat strips of gold tipped with rhodium.

In 1851, the Birmingham Exhibition in London showed gold, palladium, and silver pens tipped with iridium and osmium.

Gold pens are now usually tipped with iridium, making what are commonly known as *diamond points*. The iridium for this purpose is found in small grains in platinum, slightly alloyed with this latter metal. The gold for pens is alloyed with silver to about sixteen carats fineness, rolled into thin strips, from which the blanks are struck. The under side of the point is notched by a small circular saw to receive the iridium point, which is selected with the aid of a microscope. A flux of borax and a blow-pipe secure it to its place. The point is then ground on a copper wheel with emery. The pen-blank is next rolled to the requisite thinness by means of rollers especially adapted to the purpose, and tempered by blows from a hammer. It is then trimmed around the edges, stamped, and formed in a press. The slit is next cut through the solid iridium point by means of a thin copper wheel fed with fine emery, and a saw extends the aperture along the pen itself. The inside edges of the slit are smoothed and polished by the emery-wheel; burnishing, and hammering produce the proper degree of elasticity.

Gold-print'ing. Work printed with gold-size and the letters then covered with gold-leaf, or Dutch-metal.

Gold-rain. (*Pyrotechnics.*) Small cubes ½ inch square, used instead of stars for rockets, etc.

Their composition is niter, 16; sulphur, 10; mealed powder, 4; lamp-black, 3; flowers of zinc, 1; gum arabic, 1; treated in the same manner as for stars.

Gold-shell. Powdered gold or gold-leaf ground up with gum-water and spread on shells. Used by artists.

Gold-size. A size used as a surface on which to apply gold-leaf.

The *oil gold-size* is a mixture of linseed-oil or *fat-oil* and ocher ground by the muller and used in *oil gilding*.

The *gold-size* used in *burnish-gilding* is a peculiar composition, consisting of pipe-clay, red chalk, black-lead, suet, and bullocks' blood, compounded and thinned with a solution of gelatine.

Gold-sol'der. Gold, 12; silver, 2; copper, 4. See SOLDERS, p. 63.

Gold-thread. Otherwise *spun-gold*. A flatted, silver-gilt wire, wrapped or laid on a thread of yellow silk by twisting with a wheel or bobbins.

Gold-tis'sue. Cloth interwoven with gold-thread.

The Persians in the time of Darius were prodigal in vestments of gold embroidery and silk. The nuptial robes of Maria, wife of Honorius, discovered in her coffin in Rome in 1544, on being burned yielded thirty-four pounds of pure gold.

Gold-tool'ing. Ornaments impressed by the hot-tool upon gold-leaf laid on book-covers, causing the metal to adhere. In contradistinction to *blind-tooling*, which is the tool-mark without the leaf. The gold is fixed to the surface of the leather by gold-size, and the surplus is wiped off after the tool has been applied.

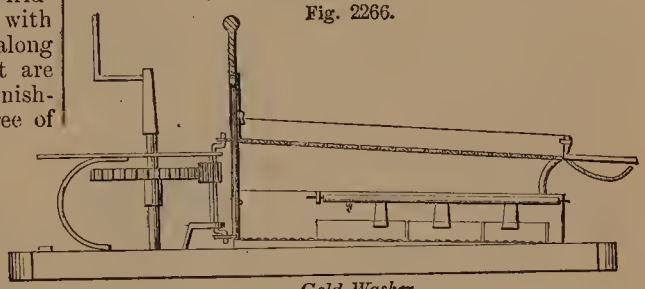
Gold-var'nish. (*Metallurgy.*) A yellow, transparent varnish spread over silver-leaf to give it the appearance of gold. The invention seems to have originated about 1680 with Antonino Cento, an artist of Palermo. It was introduced into England by Evelyn, 1680. The varnish is made of gum lac digested in spirits of wine.

Gold-wash'ers. Pliny speaks of the method of gathering gold by means of an artificial river and sluices, the water being brought from a distance by canals, and precipitated upon the auriferous earth, which is carried down the trenches, the particles of gold being arrested by the leaves of a prickly shrub planted therein. He says that the water is sometimes brought as much as one hundred miles, the channel being hollowed out of the faces of the precipices and carried by aqueducts across valleys. The prickly plant, the *ulex*, is then dried and burned, and the ashes washed to obtain the gold.

"In the country of the Saones [in the Caucasus] the winter torrents are said to bring down even gold, which the barbarians collect in troughs pierced with holes and lined with sheep fleeces; hence the fable of the "golden fleece" (STRABO). Colchis may be considered the California of old times.

Gold-washers are of various kinds, a number of

Fig. 2266.



Gold-Washer.

which are cited under GOLD-MINING, the machines and devices being also enumerated in the specific index METALLURGY (which see). The pan, the rocking-cradle, the shaking-table (Fig. 2266), the inclined chute, the series of settling-vats, the trough with slats or riffles, the vertically reciprocated sieve, are types of machines which have many varieties and names. The nomenclature of mining is very full, but a large number of its terms are local. In England the miners of Derbyshire and Cornwall have, to some extent, their own sets of terms, and these differ in many respects from those which obtain in the coal regions. See specific list under MINING.

Edrisi, the Arab geographer (about 1150), the friend of Roger II. of Sicily, speaks of the employment of quicksilver in the gold-washings made by the negroes of Sofala as a long-known practice, and the use of this metal in gathering gold has increased with the lapse of time. See AMALGAMATOR.

Gold-wire. Gold-wire, so called, has usually a core of silver, and is made by preparing a round bar of silver, plating it thickly with gold, and then drawing it through a series of holes of gradually decreasing diameter. The gold may be $\frac{1}{100}$ of the thickness of the silver at first and shares all its mutations in the drawing, retaining the same relative

thickness. Dr. Wollaston, a man of extraordinary tact in delicate experiments, made the finest wire on record. He bored out a rod of silver, put in it a core of gold-wire, then drew the rod down to wire, dissolved away the silver in nitric acid.

Gold-wire flattened by being passed between highly polished steel rollers forms a ribbon which is twisted around a core of silk to form gold-lace. The compound thread is then twisted or woven into a lace or braid.

Gol'path-en. (*Fabric.*) An Indian striped silk.

Gome; Gorm. Grease for cart-wheels (English).

Gon'do-la. 1. A Venetian pleasure-boat.

"Didst ever see a Gondola? For fear
You should not, I'll describe it you exactly:
'T is a long covered boat that 's common here,
Carved at the prow, built lightly but compactly;
Rowed by two rowers, each called 'Gondolier,'
It glides along the water looking blackly,
Just like a coffin clapt in a canoe,
Where none can make out what you say or do.

'And up and down the long canals they go,
And under the Rialto shoot along,
By night and day, all paces, swift or slow,
And round the theaters, a sable throng,
They wait in their dusk livery of woe,—
But not to them do woful things belong,
For sometimes they contain a deal of fun,
Like mourning coaches when the funeral 's done."

LORD BYRON (*Beppo*).

A gondola of middle size is 30 feet long, 4 feet beam, and is rowed by one man standing at the stern and using one oar. It has a well-furnished cabin amidship, and is painted black. The stem and stern rise in pointed elevations, the former being surmounted by the *ferro*, a bright iron cleaver.

"Two Gundaloes were imported into England by the 'merry monarch' in 1661." — PEPYS'S *Diary*.

2. A flat-bottomed boat (United States).

3. A railroad platform car.

Gong. A Malayan word. A tambourine-shaped resonant bell of the East. A disk of thin bronze with an upturned flange forming a rim. It consists, according to Klaproth, of seventy-eight parts copper, twenty-two parts tin, and is a noisy affair requiring skill in the manufacture, both in the hammering and annealing. The tempering is the inverse of that adopted for iron. The bronze is of such proportions as to be naturally brittle when cast. It is heated to a cherry red and plunged into water, being clamped between iron disks till cool. It will then bear the hammer.

2. A stationary bell whose tongue is moved by a wire or string. Commonly used as an alarm or *call-bell*.

Gon-i-om'eter. An instrument for measuring angles, more particularly those of crystals.

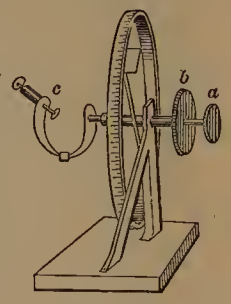
One form of goniometer for measuring the angles of crystals observed through the microscope is attached to the eye-piece, and has a pointer and graduated circle. It was invented by Romá de Lisle, about 1783.

Schmidt's goniometer consists of a positive eye-piece with a single cobweb filament stretched diametrically across it in a circular frame capable of rotation; the edges of the frame are graduated in degrees. By rotation of the frame the filament is placed successively in line with the directions of the two sides of the crystal, and the difference in the degrees is observed.

Wollaston's reflecting goniometer consists of a graduated circle provided with a vernier reading to minutes. The axis of the circle is a hollow tube within which is a smaller axis, each of which has a milled head *a b*, allowing the smaller axis to be turned independently of the circle.

The crystal to be examined is inserted in the holder *c* and fixed by wax, so that its edge may be parallel to the axis of motion; this adjustment is determined by causing a horizontal line seen by reflection from each face of the crystal to coincide with another horizontal line viewed by direct vision. The instrument is then turned until the horizontal object is seen reflected in one of the faces. The smaller axis is then held fast, and the other turned until the index of the vernier is brought to the zero of the graduated limb. The circle with the smaller axis is then turned around till the same object is seen by reflection in the other face of the crystal. The arc passed through by the circle measures the supplement of the angle formed by the two faces of the crystal, and for convenience the supplements are laid down on the circle so that the angle is read directly, avoiding the trouble of calculation.

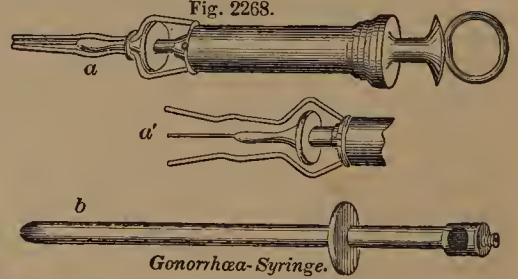
Fig. 2267.



Goniometer.

Gon'or-rhœ'a-syr'inge. (*Surgical.*) An instrument for injecting the urethra. The illustration shows an instrument *a a'* which has a nozzle and three distending fingers. It is introduced in the form shown at *a*, and then distended so as to expand the urethral wall and expose it more fully to the action of the liquid which is ejected at the nozzle. *b* is a form of urethral irrigator having rows of holes throughout a sufficient portion of its length.

Fig. 2268.



Gonorrhœa-Syringe.

Goods-wag'on. The English term for a railway freight-car.

Goose. A tailor's smoothing and pressing iron.

Goose-neck. 1. (*Nautical.*) *a.* An iron fitted at the end of a yard or boom for various purposes.

b. A *davit*.

2. (*Hydraulics.*) A nozzle having a universal-joint connection to the stand-pipe on a fire-engine.

Goose-wing. (*Nautical.*) Another name for studding-sail.

Go--out. (*Hydraulic Engineering.*) A sluice in an embankment for allowing water to escape from tidal lands when the tide is out.

Gore. 1. An angular piece of cloth at the narrowing part of a sail.

2. An angular piece of planking used in fitting the skin of a vessel to the frames.

3. An angular piece inserted into a garment to enlarge or strengthen it. A *gusset*.

Gore-strake. (*Shipbuilding.*) A strake which terminates before reaching the stem or stern-post. Such strakes are at or near the center of the ship to lessen the *spiling* of the plank.

Gorge. 1. (*Fortification.*) A line joining the inner extremities of a work; as, —

A line drawn between the rear ends of the faces of a *redan*.

A line across the narrow portion of a *bastion*, from the points of junction of its *flanks* with the *curtains*.

2. (*Masonry.*) A small groove at the under side of a coping, to keep the drip from reaching the wall. A *throat*.

3. (*Nautical.*) The *groove* or *score* of a pulley.

Gorge-hook. Two fish-hooks separated by a piece of lead.

Gor'get. (*Surgical.*) *a.* A lithotomic cutting-instrument.

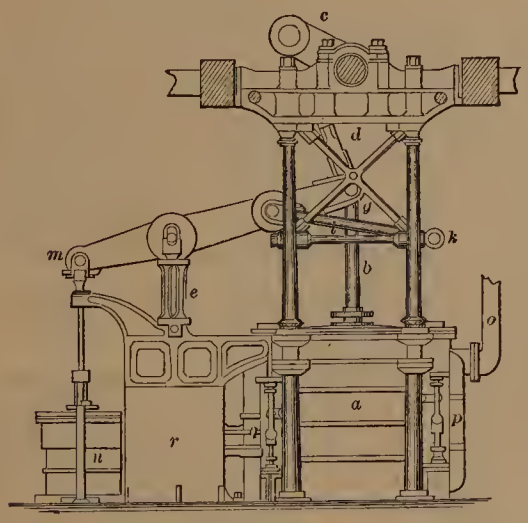
b. A canulated or concave conductor; called also a *blunt gorget*.

Gor'gon-elle'. (*Fabric.*) A Dutch cloth.

Gor'gon Steam-en'gine. A form of direct-action steam-engine, invented by Seaward (Britain), as a means of obviating the use of the beam in *marine-engines*. It is called the "*Gorgon*" engine, from having been first employed in an English government steamer of that name.

a is the steam-cylinder and *b* the piston-rod, which is connected to the crank *c* by the rod *d*. The head of the piston-rod is guided vertically by the parallel motion, as follows: *e* is a rocking standard, carrying at its upper end the fulcrum upon which the beam turns. The beam is jointed at *g* to the cross-head

Fig. 2269.



Seaward's Direct-Action Engine.

of the piston-rod, and also to the radius bar *i*, which turns upon *k* as a center. The outer end *m* of the beam serves to work the air-pump *n*. *o* is the steam-pipe by which steam is conducted to the valve-chamber *p*. *q* is the valve-chamber of the eduction-valve, which is connected to the condenser *r*, the upper portion of which forms the hot-well.

Gos'sa-mer. (*Fabric.*) A very thin gauze.

Gouge. 1. (*Wood-working.*) A chisel with a curved blade adapted to make a rounded groove in cutting or turning wood.

They are known as *flat*, *middle*, and *quick*; their curves being respectively *obtuse*, *medium*, and *acute*.

The gouge existed in early ages in stone, bone, and bronze.

2. (*Bookbinding.*) A finisher's hand-tool for blind-tooling or gilding, having a face which forms a curve.

3. A shaped incising-tool used for cutting out forms or blanks for gloves, envelopes, or other objects cut to a shape from fabric, leather, or paper.

Gouge-bit. A wood-boring tool used in a brace. It has a rounded end, and a groove which contains the chips. See Bit.

Gouge-slip. Oil-stone or hone slip, for sharpening on the concave side of the edge of the gouge.

Gov'ern-or. 1. (*Steam-engine.*) A device which regulates the admission of steam to the engine according to the rate of motion. The intention is to maintain uniform velocity, and any acceleration of speed above a given rate causes a valve to be partially closed, diminishing the area of steam passage; contrariwise in case of flagging in the speed of motion of the engine. The favorite form of governor has a pair of balls suspended from a vertical shaft, so as to swing outward when the shaft is rotated. The greater the speed the greater the centrifugal force, and consequently the farther the balls depart from the axis of rotation; the inclination of the ball arms is made effective in working the valve.

This use of the device of the two suspended revolving balls, whose circle of revolution widens as the speed of the engine increases, is due to James Watt, who adapted it from an ancient device in windmills.

The full-page engraving opposite to page 998 shows fifteen variations in form and structure of the ball-governor, two forms in which a propeller-wheel acts in a liquid, and one form in which the pressure of steam is directly upon the valve.

In *a* the balls receive their rotation from the bevel gearing above, increment of speed causing the balls to fly outward and raise the sliding sleeve on the spindle. To this sleeve is connected the end of a lever arm whose vertical oscillations are communicated to the butterfly or throttle valve, as in Figs. *k* or *l*.

In *b*, the balls receive rotation by the bevel wheels, next below the sliding collar. To the collar is attached a sleeve on which the lower bevel-gears remain at rest as long as the pin on the said sleeve is not in contact with either of the studs projecting from the upper and lower surfaces of the respective bevel-wheels. This is the position shown in the cut, and is that assumed when the engine is running at the required speed. Should the speed be accelerated, the raising of the balls would raise the sleeve and its pin, and thereby rotate the upper bevel-wheel, turning in one direction the miter-wheel with which it engages. If the speed fall below the medium, the pin on the sleeve falls and turns the other bevel-wheel, moving the miter-wheel in the other direction. The horizontal shaft of the miter-wheel operates the throttle valve or gate of the pen-stock.

c acts by substantially the same means through a system of levers upon a belt-shifter. In the medium position the belt runs on a loose pulley; but when the balls rise by acceleration of speed or fall by retardation, the belt is shifted on to the upper or the lower pulley, which pulleys act upon the valve or gate requiring adjustment.

In *d*, instead of the arms being connected with a slide working on a spindle, they cross each other and are elongated upwardly, where they connect with the valve-rod by two short links.

Pickering's governor *e* has balls on springs, the upper ends of which are attached to a collar fixed on the spindle, and the lower end to a collar on the sliding sleeve. The springs bend outward proportionally to the centrifugal force of the balls, and thereby raise the sleeve, acting upon a rod which diminishes the area of induction steam opening. A diminution of speed has the contrary effect.

In *f* the balls ascend the parabolic arms as they fly outward when the motion of the engine is accelerated, and conversely. Anti-friction wheels assist

the balls in the ascent. Rods from the axes of the rollers connect to a collar whose motions are communicated to a lever which acts upon the butterfly-valve.

In *g* the upper ends of the ball-arms have cogged sectors which act upon the racks on the axial-rod to depress or raise it.

In *h* the oscillating weighted arm assumes a more horizontal position with increase of speed. Its normal or stationary position is shown in the illustration, its arms being out of poise.

i has balls upon toggle-arms, and resembles figure *e*, in which they are on springs.

In *j* the elbows of the arms are connected by a spring whose midlength is attached to a sleeve which slips on the spindle as the balls rise or fall.

k shows the connection of a governor similar to *a*, with the butterfly-valve of a steam-pipe ; and *l* is an illustration of a governor similar to *d*, but driven by a band-wheel below.

Tyson's governor *m m'*, 1861, has its arms suspended from a horizontal axis which rotates with the vertical spindle. He states that his object is to avoid "the friction which resists the free movement of the weighted arms in ordinary governors and attain the desirable sensitiveness." *m* is an elevation, and *m'* a plan view looking upon the balls in motion, showing them swinging tangentially to a circle whose radius is equal to the length of the axis of suspension. When the engine starts, their inertia first comes into play, and increment of speed causes them to rise in the prescribed planes, the balls themselves describing an orbit of increasing radius. It is supposed to be more sensitive than the form in which the balls swing radially outward, but, like them, has the disadvantage of lateral pressure in its bearings, as the balls are compelled to rise in lines which are not the natural result of the forces which actuate them. In Tyson's the line of rise and fall is tangential to a circle of given radius ; in the ordinary governor it is directly radial.

In Shive's governor, *n n'*, the balls swing at an angle which is, as seen at *n'*, a compromise between the two last described. The axes of the mandrels on which the ball arms vibrate are tangential to the spindle, at a point distant about the semi-diameter of the ball from the axis of revolution of the vertical spindle. The balls thus swing outwardly and backwardly, so that the inertia as well as centrifugal action of the balls, is brought into play. They are, however, compelled to rise in the prescribed direction, a compromise between the radial and the tangential.

Degener's governor, 1856, was designed to give to the pendulum balls "a motion independent of the motion of the spindle aside from their vibratory motion, by means of the diverging spiral inclines . . . . for the purpose of obtaining a more sensitive action of the pendulums." The collar from which the pendulums are swung is allowed to turn upon the spindle. The spirals are intended to "act under the pendulums and assist in throwing them upward" when the rate is increasing, or downward when the speed is checked. The diverging spiral inclines are of a shape approximating the line of ascent and descent of the ball arms under increment and decrement of speed, and can only permit freedom of motion at one ratio of increase or decrease of speed. Freedom of motion is, however, not intended, but the inclines are intended to compel quick response.

In Knight's governor, Figs. *o*, *o'*, *o''*, *o'''*, the hinging axis of each ball arm has a capacity for adjustment in a plane at right angles to the axis of revolution, so that as the hinging axis permits the vertical motion of the ball, the adjustment in a horizontal plane of the bearing of the said hinging axis shall permit the outward swing of the ball, the two, in fact, forming a universal joint permitting the ball to follow the line of motion due to the speed and the proportions of the parts. In cases where the balls are compelled to rise in a certain plane, they can only do so with perfect freedom when running at one definite speed, and their motion on their hinging axes can never be perfectly free when running above or below the said definite rate ; this fact is recognized by the introduction of the usual guides, as at *a b c d k l*, which prescribe the path of motion, and which would be unnecessary were the actions of the balls unconstrained. Any guide or immovable axis which tends to warp the balls from their true line of motion affects the freedom of their movements, entails additional friction, and intercepts or prevents their delicate and instant response to an acceleration or retardation of speed. If, upon an increase of speed, the arms or hinging joints of the balls have a tendency by a lateral strain or pressure to bind or rub, it is manifest that the balls cannot instantly respond, but that a cumulative force and speed will be required to obtain such a response as would more quickly result were the balls perfectly free to respond in their own way ; and, in fact, the motion due to the inertia of the balls developed upon an accession of speed and manifested by their tendency to lag behind is much more immediately responsive and active than the tendency to assume a more radial relative position which presently results. In this governor the balls are free to swing in such direction as may be induced by their speed and proportions, ascending or descending under changes of speed in such curves as may result from the combined forces of gravity and centrifugal impulse, under the condition of free pivotal attachment to bearings which are permitted to rotate in a horizontal plane.

Fig. *o* is an elevation of one mode of application of this principle, the balls swinging upward.

o' is a top view of the same.

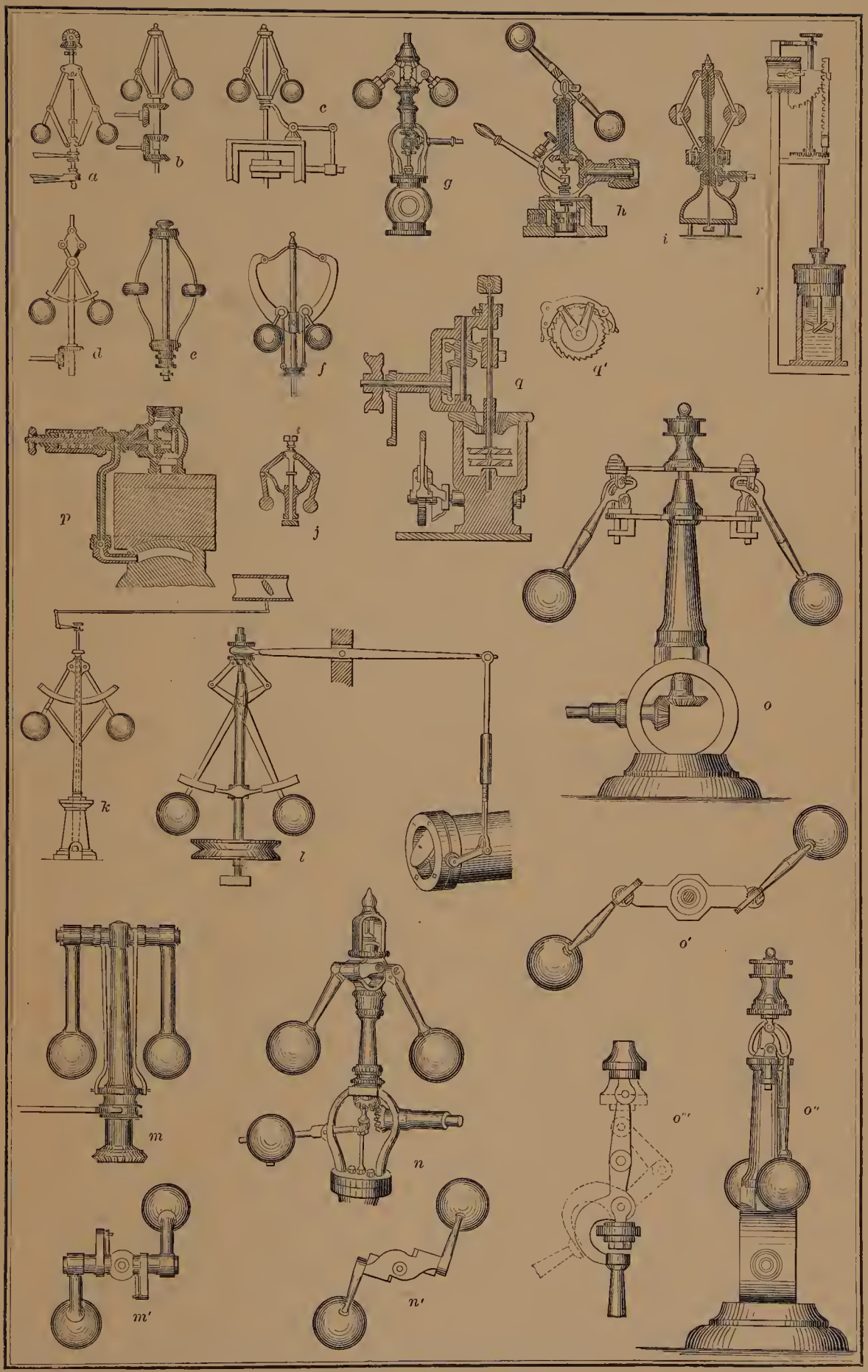
o'' shows the balls at rest ; *o'''* is another form in which a spur or finger from above the hinging joint of the governor arm projects upward, and is jointed to a link pivoted above to a spindle in the plate ; the finger and link together form a toggle, which brings the upper plate nearer to the lower one, the two ends of the toggle being hinged in bearings which are capable of horizontal rotation in the respective plates. The downward motion of the balls restores the normal position. The parts may be so arranged as to straighten the toggle by the raising of the ball, if so desired.

Modifications are shown in the patents whereby either the tangential or radial motions of the ball may be utilized, or an effect obtained from the sum of the two motions.

Some other forms than the pendulous ball may be referred to.

p is a governor in which the valve is operated by the direct pressure of steam upon a piston on its stem. The piston operates in a smaller cylinder, taking steam from the main cylinder.

q q' is Huntoon's hydraulic governor, in which a propeller-wheel works in a liquid whose resistance causes the propeller-shaft to rise in a degree proportioned to the rate of speed. The sectoral frame with its draw-pawls has a constant, reciprocating, rotary motion, and when either of the pawls comes in contact with the ratchet, it causes the ratchet-shaft to rotate to actuate the steam-valve. The rocker-frame is actu-



STEAM-ENGINE GOVERNORS.

PLATE XXI.

See page 998.

ated by the governor, and its cams bring one or other of the pawls in contact with the ratchet, according to the variation of the speed above or below the desired point.

r is a somewhat similar contrivance, in which the longitudinal position of the propeller in the water-cylinder, due to its rate of speed, determines by the connecting rack and segment the position of the valve in the steam-pipe.

Silver's momentum-wheel governor has a heavy revolving wheel, whose momentum acts upon the throttle-valve when any change occurs in the rate of motion of the engine. See also MARINE-GOVERNOR.

The *hydraulic governor* or *cataract* is the invention of Smeaton. A quantity of water is pumped at each stroke, and forced by counter weights through an orifice of a certain size. See CATARACT.

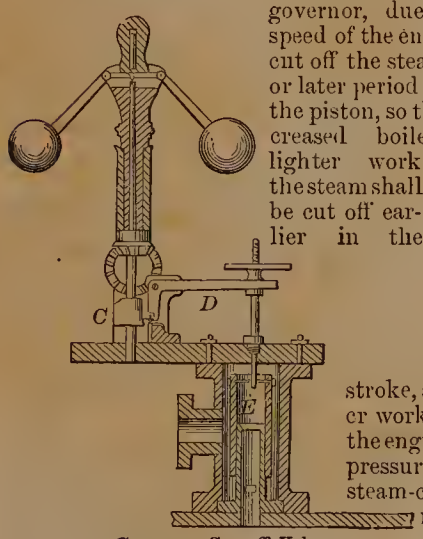
Davis's governor (English) consists of a single hollow ball with a zone round it, having an opening through the bottom to admit of an upright spindle, attached to the ball by a joint in its center. One side of the ball and zone is made much heavier than the other, and consequently, when at rest or moving slowly, it hangs down; but when driven fast, the centrifugal force of the heavy side overcomes its gravity, and the zone assumes a nearly horizontal position. When this is the case, a small link inside the ball, jointed on one side of the axis, lowers the usual brass collar on the spindle, and shuts off part of the steam, till the diminishing speed allows the gravity of the zone to overcome the centrifugal force, and, the link being raised, the throttle-valve is opened under to admit more steam.

In Mosman's chronometric governor, one of two shafts has rotation directly from the engine, its speed being relative to that of the engine. The other shaft has motion from the engine, but its speed is regulated by a pendulum or balance-wheel. A variation in speed causes a longitudinal movement in the shaft which is connected to the governor valve.

2. (*Gas.*) A device which regulates the passage of gas from the holder to the mains, admitting it thereto in quantities determined by the rate at which it is used. The pressure in the mains determines the area of the opening through which the gas enters. See GAS-GOVERNOR.

Gov'ern-or Cut-off. An automatic arrangement in which the acceleration or retardation of the motion of the governor, due to changes of speed of the engine, is made to cut off the steam at an earlier or later period of the stroke of the piston, so that with the increased boiler-pressure or lighter work the steam shall be cut off earlier in the stroke, and when greater work is imposed on the engine or the steam-pressure flags, the steam-cylinder shall receive steam from the boiler during a larger proportion of the stroke of the piston.

Fig. 2270.



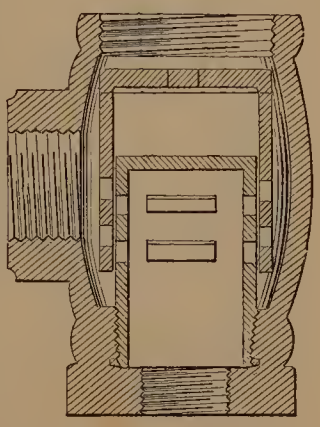
Governor Cut-off Valve.

The combination of the governor with a cut-off valve-gear was first published in the "Repertory of Patent Inventions" for 1826, as the invention of James Whitelaw.

There are many forms of this device, and the applications are made to slide and to puppet valves. In the illustration it is shown as applied to a cylindrical valve. The variable cam *C* on the stem which is raised or depressed by the vertical motions of the governor-balls makes two revolutions to each stroke of the engine. The two distinct fields of the cam have different radii, and act upon the short arm of a bell-crank lever *D* connected at its other end to the stem of a balanced cylinder-valve *E*, which governs the admission of steam to the cylinder.

Gov'ern-or-valve. 1. A valve in a steam-pipe operated by the governor to vary the area of steam, opening according to the rate of moving, and consequently the requirement of the engine; the object being to maintain a uniform rate.

Fig. 2271.

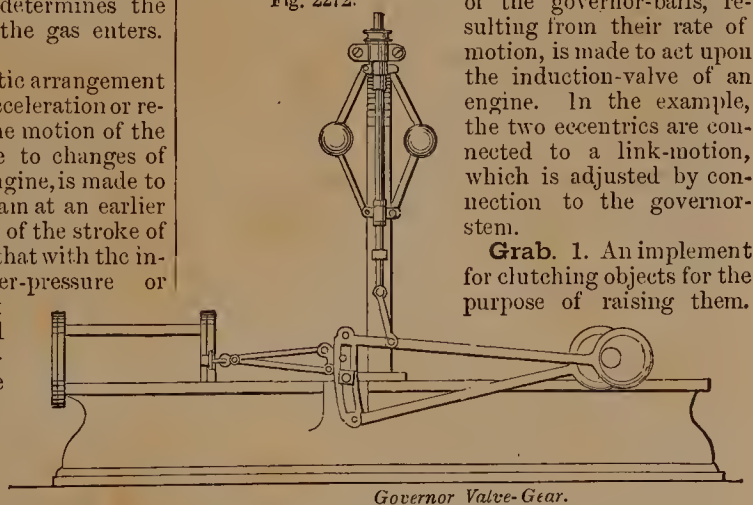


Governor-Valve.

2. A governor cut-off is an induction-valve in a steam-chest, so connected to the governor as to be influenced in its throw by the speed of the latter. When the governor runs at accelerated speed, the period of induction of steam is at the shortest, and the steam is used expansively. When the rate is depressed, the steam induction-port is kept open for a longer time. This variation in the action of the valve is automatic, and derived from the governor. See GOVERNOR.

Gov'ern-or-valve Gear. An arrangement of parts whereby the position of the governor-balls, resulting from their rate of motion, is made to act upon the induction-valve of an engine. In the example, the two eccentrics are connected to a link-motion, which is adjusted by connection to the governor-stem.

Fig. 2272.



Governor Valve-Gear.

Grab. 1. An implement for clutching objects for the purpose of raising them. The term is specially applied to devices for withdrawing pipes, drills, reamers, etc., from artesian, oil, and other wells which are drilled, bored, or driven.

Two forms are shown: one has a pair of serrated jaws, which embrace the pipe or rod and bite upon it when the grab is lifted.

In the other form, the serrated jaws of the hollow cylinder are driven down upon the tool to be extracted, and by their inclined rear faces and locking

collar grasp the same when the grab is lifted. To detach the grab, the collar is lifted by the hook.

Fig. 2273.

Fig 2274.

Grabs.

2. A large East Indian coaster, two masted, with a prow stern, and of from 150 to 300 tons' burden.

Grade. The inclination from the horizontal of a portion of a road or railroad. It is expressed in degrees, in feet per mile, or as a foot in such a distance; as, —

A grade of 3°.

A grade of 35 feet per mile.

A grade of 1 foot in 240. See INCLINED PLANE.

Gra'di-ent. (*Civil Engineering.*) The inclination of a slope.

Gra'di-ent-post. 1. (*Railroad Engineering.*) One placed by the side of the track, at a change of grade, carrying a board slanted to the slope and indicating in figures the grade in feet per 100, or otherwise.

2. A stake set in the ground and marked to indicate the proper hight of an embankment or of road metal at that point.

Gra-dine'. A toothed chisel used by sculptors. See MARTELINE.

Grad'ing-in'stru-ment. A level with an alidade, a transit or other sighting instrument, by which the angle of inclination of a slope may be measured, or a row of stakes driven to mark a given gradient.

Grad'ing-plow. One used for breaking up soil or plowing down banks, in order to fit the earth for being scooped up by the earth-scraper, and thereby deported.

Grad'ing-scrap'er. A large two-handled shovel drawn by a pair of horses and used as an earth-scoop for raising and removing loosened earth. It is used in road-making, scooping out beds of canals in certain situations, and otherwhere when the soil is suitable and the distance where it is to be deposited is not too great. See EARTH-SCRAPER.

Grad'u-at-ing-in'stru-ment. The work of graduating or dividing instruments of precision, though now very generally performed automatically, was formerly effected entirely by hand, by stepping off the successive divisions of the scale or circle, or by successive bisections of a line or chord. This latter naturally suggests itself with regard to a line, but with a circular arc the case is different; there, if it is desired, as is universally the case, to preserve the division into degrees, after the radius has been applied six times to the circumference, giving arcs of 60°, the farther subdivision requires trisections and even divisions into fifths, operations which are very difficult to perform in practice without the aid of very accurately constructed mechanism.

Roemer, in constructing a circle, decided rather to rely on stepping-off arcs of about 10, and applying a subsequent correction for any discrepancy which should exist between the number actually laid down and that which should be contained in a quadrant of the circle. Dr. Hooke proposed the employment of an endless screw for dividing the edge of his quadrant, and this was actually used by Tompion in graduating Flamsteed's sector, probably under the supervision of Hooke.

Graham, who attained great reputation as an instrument-maker as well as clock-maker, adopted the principle of continuous bisections by means of a beam-compass. In the instruments constructed by him for Halley and Bradley, the arc of 60° was divided into 64 parts, making 96° instead of 90° to the quadrant. It was deemed preferable to make the proportionate correction on each angle, rather than to trust to the uncertainty of a division to thirds or fifths.

Bird, 1750, subsequently improved the system by constructing scales of equal parts, enabling him to preserve the division of 90° by successive bisections. His manual skill and care procured him merited reputation as a maker of accurate instruments.

Ramsden followed with his dividing-engine, 1766, the general principles of which, variously modified and improved by Troughton and others, are still employed in the construction of like instruments.

In this, a horizontal wheel, turning on a vertical axis, has a toothed edge, which is advanced a certain amount, say 10′ of arc by each revolution of an endless screw with which it gears. The screw is turned by a treadle, the connecting mechanism being such that it may be adjusted to turn a whole revolution or any desired part of a revolution by a movement of the treadle.

For this invention he received a reward of £600 from the British government, on condition of executing the divisions on the instruments of other makers at a fixed price for each instrument. An instrument of this kind, by Troughton & Sims, is in the Coast Survey Building, Capitol Hill, Washington.

Hindley, 1740, had invented a dividing-engine, upon which this of Troughton is said to have been based. It also served for cutting the teeth for clock-wheels. See also DIVIDING-ENGINE.

In addition to original graduation by the beam compass and engine, the dividing of a scale or a circle is performed (and this is the most common practice with regard to ordinary instruments) by means of a *dividing-plate*, which is itself originally graduated with great care. This consists of a circle carrying a pivoted straight-edge, and is fixed to and concentric with the circle to be divided. The straight-edge is moved, step by step, a distance, 10′ or 15′, indicated on the dividing-plate, and at each move a clean straight cut is made in the limb of the instrument being graduated. The knife has one flat side and somewhat resembles a graver, but is drawn toward instead of being pushed from the artist. At each degree the marks made are longer, their length, and that of the smaller divisions, being bounded by concentric circles previously described on the limb.

Froment invented a machine, driven by rotary electro-magnets, in which the object to be graduated was slowly and intermittingly pushed forward by a screw, while a fine steel or diamond point was automatically caused to make a cut at each cessation of the feeding motion. He thus succeeded in crowding 25,000 lines, with distinct and equal intervals between them, within the space of an inch. Nobert

succeeded in ruling more than eight times as fine. See NOBERT'S TEST-PLATES.

Whitworth has graduated micrometers by which the almost inappreciable quantity of one millionth of an inch can be measured. See DIVIDING-ENGINE; MEASURING-MACHINE.

Grad'u-a-ted-bot'tle. One having horizontal marks blown, pressed, or cut on its side to indicate quantity of contents at given levels. Sometimes the stopper is hollow, forms a cup, and has graduations for doses of certain amounts.

Grad'u-a'ted-cup. A medicine-cup, on whose sides are marks to indicate quantities at given levels. If of glass, they are usually impressed in the mold; if of porcelain, they are painted on the ware before burning.

Grad'u-a'ted-glass. A tube with a foot, and with horizontal marks at varying hights to indicate quantity of contents. A *measuring-glass.*

Grad'u-a'tor. An apparatus in which a solution is allowed to trickle over a large extent of surface, during which it is exposed to a current of air.

This is adopted in the salt-works of Montiers, in the Tarantaise, Switzerland, where brine having 1.83 per cent of saline matter is condensed to such a degree of saturation as to be profitably evaporated by boiling. It is trickled over fagots of thorns placed in frames, and acquires a density of 22 per cent.

Fig. 2275.

Graduator.

Another plan is to let it trickle over suspended ropes upon which it crystallizes and is broken off. The ropes last twenty-five years; the fagots, seven years.

Vinegar is manufactured by exposing a large surface to oxidation in a similar manner, the cider or alcoholic solution being suffered to trickle through a vat filled with beech shavings, through which a current of air is simultaneously passed.

Wort is cooled by trickling it over pipes through which a stream of cold water is continuously passed. (See BEER-COOLER.) In De Grand's condenser the saccharine juice is passed over a succession of steam-heated pipes, in order to condense it before reaching the vacuum-pan. See CONDENSER.

Graft'ing. 1. (*Carpentry.*) A scarfing or endwise attachment of one timber to another, as in attaching an extra length or false pile to one already driven.

2. (*Nautical.*) The tapering of the end of a rope; usually covered by weaving yarns around it.

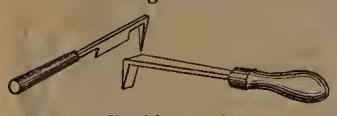
3. (*Husbandry.*) The placing of a scion of a particular variety of tree or shrub in a stock of its own or a closely allied species.

4. (*Surgical.*) The transplanting of a portion of skin to a denuded surface.

Graft'ing-chis'el. (*Husbandry.*) One for splitting a stock for the insertion of a scion.

Graft'ing-knife. A knife having a blade for splitting a limb and a wedge for opening the cleft for the insertion of the scion.

Fig. 2276.



Grafting-Knife.

It is used in connection with a mallet.

Graft'ing-saw. A tenon-saw for cutting off stocks for grafting. A *pruning-saw.*

Graft'ing-tool. A very strong spade; much curved, used in digging canals.

Graft'ing-wax. Rosin, 6; beeswax, 1; tallow, 1; melted together, to be used warm when grafting indoors. Rosin, 4 or 5; beeswax, 1½ to 2; linseed-oil, 1 to 1½, for outdoor work the proportions varying with the season and temperature. French recipe: Black pitch, 28; Burgundy pitch, 28; beeswax, 16; grease, 14; yellow ocher, 14.

Melt 4 parts beeswax; 1 part Canada balsam (balsam of fir); pour while hot on thin paper, so as to cut in strips for convenient use; a little vermilion added keeps insects from the scion.

Another grafting composition used by nurserymen is clay tempered with water, to which a little linseed-oil is sometimes added.

Graille. A *single-cut* file, or *float*, having one curved face and a straight one, used by comb-makers. See COMB.

Grain. 1. (*Weight.*) The unit of weight in the English system. 7,000 grains make one pound avoirdupois, and 5,760 grains one pound troy, or apothecary's weight. See POUND; UNIT.

2. (*Painting.*) A style of painting in imitation of the natural *grain* of wood.

3. The *hair* side of skin; in contradistinction to the *flesh* side.

4. (*Dyeing.*) Formerly, a red dye prepared from the *coccus* insect, or *kermes.* Now applied to a firm dye as one applied thoroughly; in the *wool*, not in the *web.*

5. The direction of the fibers in wood, etc., and of the strata or cleavage in stone, slate, etc.

Grain-bin. A box or a compartment in a granary or elevator in which grain is stored. In the large buildings for trans-shipping and storing grain, and known as *elevators*, the apartment at the top of the building into which the grain-cups discharge has distributing-pipes to the various bins, and these have funnel-shaped bottoms and valves for discharging their contents. See ELEVATOR.

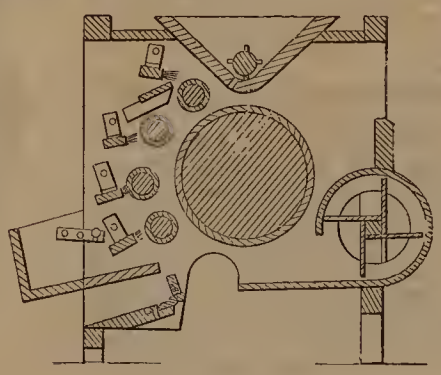
Grain-bind'er. An attachment to a harvester for binding a gavel into a sheaf. See REAPER.

Grain-bruis'er. The grain-bruiser is for mashing grain for feed, to render it more digestible. It does not amount to grinding, but crushes the kernel, corn, or oats, and puts it in a better condition for feed, for obvious reasons which need not be explained here. It is a very common practice in England, and will be here when economy is much studied. A *bruising-mill.* See GRINDING-MILL.

The machine has two iron rollers of differing diameters, which are turned by connecting cog-wheels of the same size, so that a rubbing is added to the crushing action. A fluted roller below the hopper receives the grain from the hopper and feeds it to the rolls. See OIL-CAKE BREAKER.

Grain-clean'er. 1. A machine in which wheat, oats, rye, and barley are separated from their chaff,

Fig 2277.



Grain-Cleaner.

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dust, and pieces of straw, — the result of the thrashing operation. A FANNING-MILL; a WINNOWING-MACHINE (which see).

2. The shoe or cleaning portion of a thrashing-machine which acts after the thrasher and the straw-carrier. See THRASHING-MACHINE; SEPARATOR.

3. A machine in which grain is rid of cockle, garlic, etc., which are so nearly the size and weight of the grain that the size of mesh and strength of blast of the fanning-mill are ineffective. Fig. 2277 shows one form, in which the cylinder has a hard periphery which is held in contact with the smaller rollers by springs; the latter have soft surfaces, which catch the cockle, garlic, etc., and carry it away to be removed by brushes and separately discharged, while the dust is blown away by a fan.

4. A machine in which grain is rubbed, brushed, and blown to remove smut and dust. See SMUT-MACHINE.

Grain-con-vey'or. A series of cups on an endless band, an archimedean screw, or a blast of air to carry grain in a conductor from one place to another, in a *thrasher*, *grain-cleaner*, *smut-mill*, *mill*, *warehouse*, or *elevator*.

Grain-cra'dle. A light, four-fingered frame attached to the snath of a grain-scythe so as to catch the cut grain and allow it to be laid evenly in a swath.

Our four-fingered grain-cradle, whose post is braced by rods, and whose swath has a single nib for the right hand, seems to have originated in France; Loudon (1844) speaks of it as an ordinary tool in Normandy.

Grain-damp'er. A device for applying steam to grain to scald the bran and facilitate the process of decortication. A jet of steam entering a tube where the grain descends a series of inclines is a usual method.

Grain-drill. A *grain-drill* may sow one or more rows of seed, but a *drilling-machine*, by common consent apparently, is adapted for "sowing seed in equidistant rows, on a flat surface; on the top of a narrow ridge; in the interval between two ridges; or in the bottom of a common furrow. Small grain, when drilled, is usually sown in the first of these ways, turnips in the second, and peas and beans in the third and fourth." — LOUDON.

The first notice we find of a grain-drill is in that repository of the wonderful, — China. The Chinese machine is a wheelbarrow with a hopper for the seed, and three spouts, twenty-eight inches long, by which the grain reaches the ground; it thus drills three rows at once.

It appears from a communication to the British Board of Agriculture, that a rude sort of grain-drill has been in use in India from time immemorial. It is a drilling hopper attached to a plow so as to deposit the seed in the furrow.

The first notice of a European grain-drill is one invented by a German, and presented to the court of Spain in 1647. The same drill attracted the attention of the Earl of Sandwich, who sent one to England. Evelyn, who died in 1706, speaks of it as a machine of great merit, and the invention of a Spaniard, Don Joseph de Lescatello. Worlidge, in his "Husbandry," published 1669, also recommends it. It was fastened to the tail of a plow, and dropped the seed in the furrow.

It was regarded as a curiosity merely, until a man appeared who was able to appreciate it.

The system of drill husbandry of Britain is the invention of Jethro Tull, a farmer of Berkshire, England, who was an original thinker and innovator. He introduced his system in 1701, and published his "Horse-hoeing Husbandry" in 1731. His special object in drilling was to put the plants in rows, which would allow them to be hoed by machinery. He brought brains and money to the scheme, and impoverished himself, being rather too far ahead of his time. As Loudon observes, he "had very few followers in England for more than thirty years." He died soon after the publication of his book, and his son died in a debtors' prison, when such things were. Not so very long ago.

Jethro Tull's first invention was a kind of plow, with drill attached, for sowing wheat and turnips in three rows at a time; it consisted of two seed-boxes with a colter attached to each, and following each other; behind them followed a harrow to cover in the seed. His object in having two separate deposits of seed, and at different depths, was that they might not sprout at the same time, and so perhaps escape the ravages of the fly; he also invented a turnip-drill.

About 1790, Baldwin and Wells of Norfolk, England, contrived several ingenious improvements to the machine, the first of which was in making a sliding axletree, by which the carriage-wheel could be extended when necessary to the width of the stitches (lands), and so enable another box with cups and more colters to be used. A drill containing fourteen colters could be thus enlarged to contain eighteen, or even twenty.

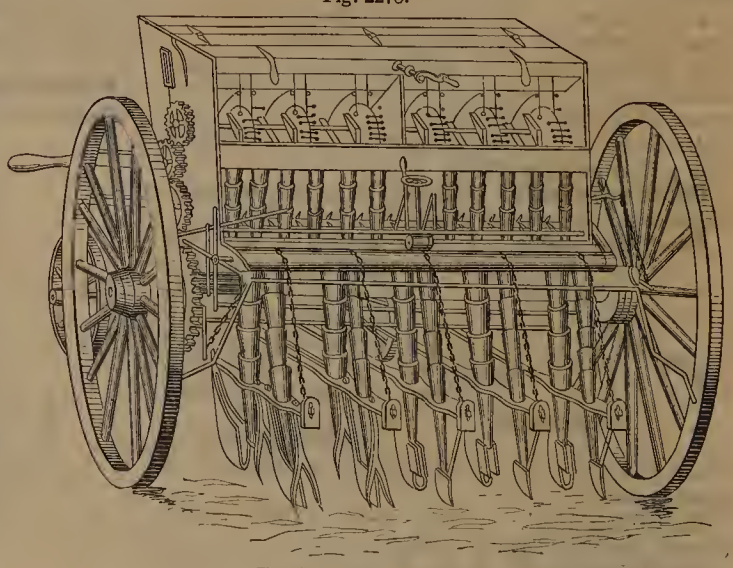
They also constructed self-regulating levers, to which the colters were attached; by hanging each colter on a separate lever, each lever swinging by an ordinary hinge-joint, and having a movable weight at the outer end to press the colter into the soil to the required depth.

After Tull, the machine was much improved by James Cooke, a clergyman, of Lancashire, England; his improvements have been adopted in almost all of the subsequent machines used in English husbandry.

Mr. Ransome states: —

"The seed-box is of a peculiar shape, the hinder part extending lower than the forepart. It is di-

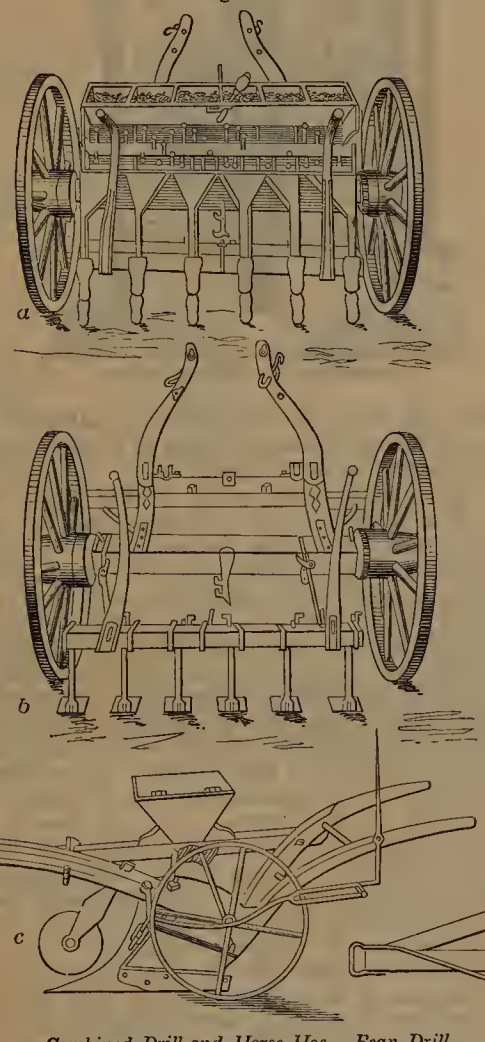
Fig. 2278.



English Grain-Drill.

vided by partitions, and supported by adjustable bearings so as to preserve a regular delivery of the seed, while the machine is passing over uneven ground. The feeding cylinder is made to revolve by a toothed wheel, which is fixed on each end of the main axle, and gears with other toothed wheels on each end of the cylinder; the surface of the cylinder is furnished with a series of cups, which revolve with it, and are of various sizes, according to the different seeds intended to be sown. These deposit the seed regularly in funnels, the lower ends of which lead immediately behind the colters,

Fig. 2279.



Combined Drill and Horse-Hoe. Bean-Drill.

which are connected by a beam so as to be kept in an even line, and are capable of being held out of working, when desired, by a hook and link in the center. The seed, as it is deposited, is covered in by a harrow fixed on behind. The carriage wheels are larger than usual, by which means the machine is more easily drawn over uneven ground, and the labor of working is reduced."

Garrett's grain-drill (English) is adapted for performing all the various operations of seeding and manuring the land. All kinds of grain and seeds may be deposited at any required distances apart, and at any depth, either with or without compost or artificial manures.

They are constructed of various widths, and made to deposit the seed in rows from six to fifteen in number, and to suit all descriptions of land, whether ploughed flat or in ridges. The corn and manure are sometimes sown through the same delivery-tubes, but it is better when double tubes and colters are adopted, as the seed is then buried two or three inches deeper than the manure (as before described), and a portion of mold placed between the two. The boxes are suspended on a center in the middle of the machine, and may be elevated or depressed, at either end, by means of a lever, so as to keep them at all times in a horizontal position, and to insure a regular delivery of both on hilly as well as on flat lands. This arrangement admits of the barrels, which deliver the manure and seeds, being driven by gear at the ends of the boxes in the usual way, thus avoiding all unnecessary complication.

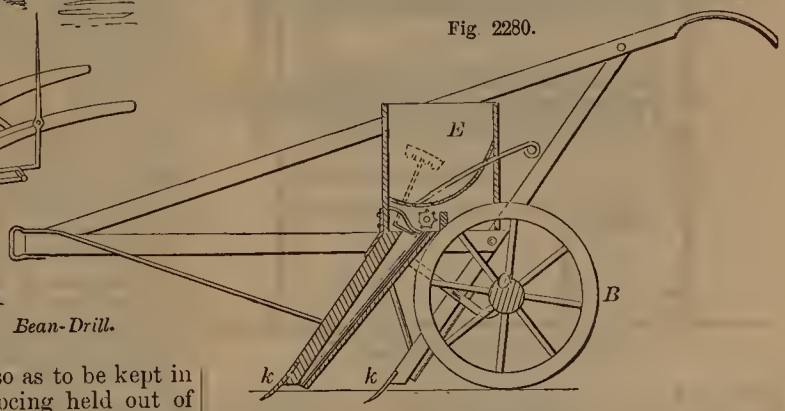
Hornsby, of England, was the first to apply india-rubber tubes as grain-spouts in place of the cumbersome tin cups.

Cooke's drill and horse-hoe *a b* (English) is a convertible machine, the seed-hoppers, shares, and grain-conductors being attached when required. When the crop is to be tended, any kind of share or colter is substituted for the seeding apparatus, as, for instance, the hoes of the illustration. These are attached to the beam previously occupied by the furrow-openers, and may be made to follow with exactness the intervals between the rows of growing plants. The beam is attached by a parallel arrangement to the carriage, and has a pair of handles by which it is swerved laterally to maintain the straight line if the horse deviate. The beam may be raised, and hooked up so as to keep the shares out of the ground during transportation or in turning.

The English bean-drill *c* draws a furrow in the prepared soil and sows a row at the same time. The wheel regulates the depth of the furrow, and a lever throws the drill out of gear when turning at the end of the land.

Fig. 2280 is a form of hand-drill, mounted upon a stock resembling a single-shovel plow, and resting upon a wheel; forward is the hollow tube shod with a share *k*, and leading the grain from the box *E*. A

Fig. 2280.



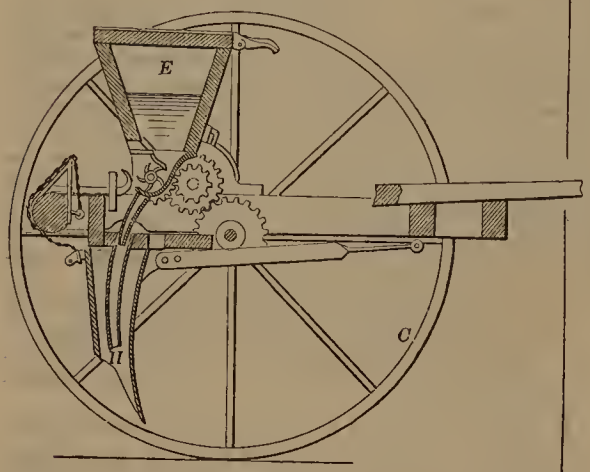
Single-Row Drill.

share *k*, following, turns a furrow upon the sown grain, and the wheel *B*, following, compacts the soil upon the seed.

Fig. 2281 is a vertical transverse section of the usual American grain-drill, which is drawn by a pair of horses, and has a gang of shares in one or two banks; some varieties of this drill have a capacity for changing to a single or double bank drill.

In the example, the feed-wheel at the bottom of the grain-box *E* is driven by gearing from the ground-wheel *C*, and discharges into india-rubber spouts which lead the seed into and through the hollow share *H*.

Fig. 2281



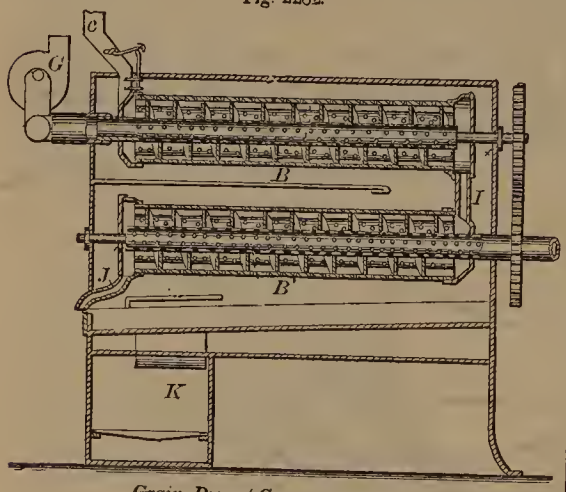
Grain-Drill.

Grain-dry'er. An apparatus or machine in which damp grain is dried, or grain in ordinary condition is kiln-dried to fit it for ocean shipment.

There are many forms of the device, which generally agree in that they afford means for exposing a shower of grain to a current of highly dried and heated air. The following kinds may be cited, and it must be understood that there are many varieties and modifications of each.

1. The *conveyor* system, in which the grain from spout *e* passes consecutively through the cylinders *B B'*, in each of which is a rotating screw conveyor driven by cog-wheels and having for axes hollow

Fig. 2282.



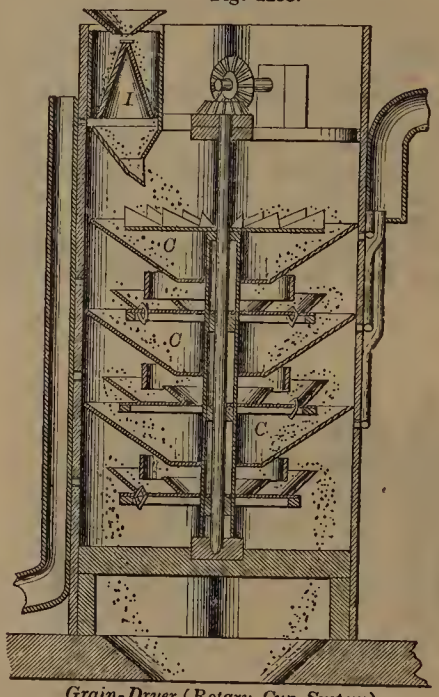
Grain-Dryer (Conveyor System).

perforated tubes, through which the damp air passes from the grain, being drawn by the exhaust fan *G*. The cylinders connect by the spout *I*, and the lower one discharges by the spout *J*. The heated air from furnace *K* rises into the chamber above and surrounds the cylinders.

2. The *revolving-cup* system. In the example the grain enters upon a heated cone *I*, and thence passes to a revolving flanged disk which distributes it to be again collected by the hopper *C*, fed to another disk, and so on down through, in descending series, to the discharge-spout. A current of heated air ascends through the chamber and envelops the grain at all times.

3. The *zigzag-incline* system, shown at *A* (Fig. 2284). The grain descends from a hopper and is

Fig. 2283.



Grain-Dryer (Rotary-Cup System).

shifted over from side to side by the alternate inclines, which are perforated plates in a flue occupied by an upward current of heated air.

4. The *annular drum system B* (Fig. 2284) consists of a vertical double cylindrical chamber with conical ends. The space between the inner and outer casing is the one traversed by the grain, which enters at the apex of the upper cone and departs at the apex of the lower one. The inner and outer casings are all perforated with holes, about 2,300 to the square foot, and the punching being from without, inward, the slight roughness has a tendency to turn the grain which rubs against the protuberances, giving a sort of stirring action to the grain, and aiding the exposure of its whole surface to the stream of heated air. The heat is generated by a stove in the interior of the chamber, and the heated air passes through both casings and through the body of grain contained between them. The apparatus stands upon legs so as to elevate the discharge opening that the falling grain may be received into sacks or grain-barrows for shipping or binning.

A damper or valve at the discharge opening regulates the area of the exit orifice, and thus governs the speed of the passage, determining thereby the time which the grain shall occupy in its transit, according to its condition and the necessities of the case.

5. The *spiral-flue* system *C*, which consists of a long spiral tube traversed by a flue from a stove. The sides of the tube are full of fine perforations, and the draft is upward between the two surfaces and outward through the perforations, carrying the moisture from the grain, which descends in a shower between the flue-pipe and the perforated casing.

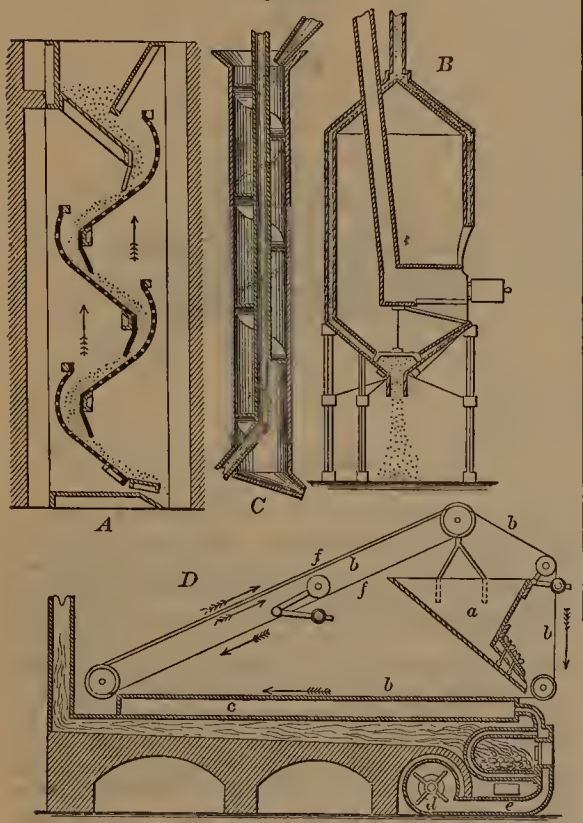
6. The *traveling-belt* system *D* consists of a furnace air-box and traveling-belt which receives its grain from a hopper. Grain from hopper *a* falls on to belt *b*, which travels over the grated top of the box *c*, which is heated by air from fan *d* and tubes *e* which form the box and basket grate of the furnace. After passing the length of the box the grain is caught between the belts *b* and *f* and returned to the hopper for a repetition of the operation, or as it descends is intercepted by a spout.

7. The *rotary-drum* system, in which an inclined cylinder of wire contains the grain which tumbles over and over, and eventually is discharged at the lower end of the cylinder, which rotates in a chamber heated by a furnace.

8. The *floor-and-scraper* system, in which grain passes from floor to floor, scrapers distributing and discharging it on and from the respective floors in the series.

E F (Fig. 2284) show two forms of this. In *E* the upright cylindrical chamber has a series of cir-

Fig. 2284.



Grain-Dryers.

cular perforated floors, with alternate central and marginal discharge apertures. Rotary conveyors, alternately centrifugal and centripetal, convey to the apertures the grain which falls from floor to floor.

In the other example *F* the grain is moved alternately to the right and left, over finely perforated plates, by the slats or endless chains which pass over the plates. Hot air from a blast or other means passes upward through the plates and grain. The grain drops from the end of each plate to the one immediately beneath.

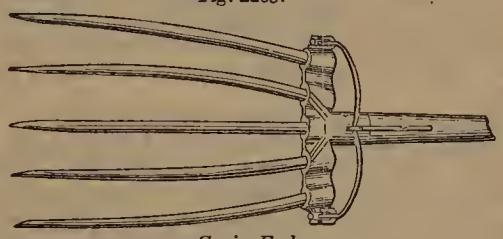
Grain'er. 1. The brush used in *graining* or imitating woods.

2. An infusion of pigeon's dung for giving flexibility to skins in the process of tanning. Also called *bate*.

3. A knife used by tanners.

Grain-fork. A light fork with long and curved tines, used for pitching gavels of cut grain on to a

Fig. 2285.



Grain-Fork.

wagon when the straw is too short for convenient binding. A *barley*-fork.

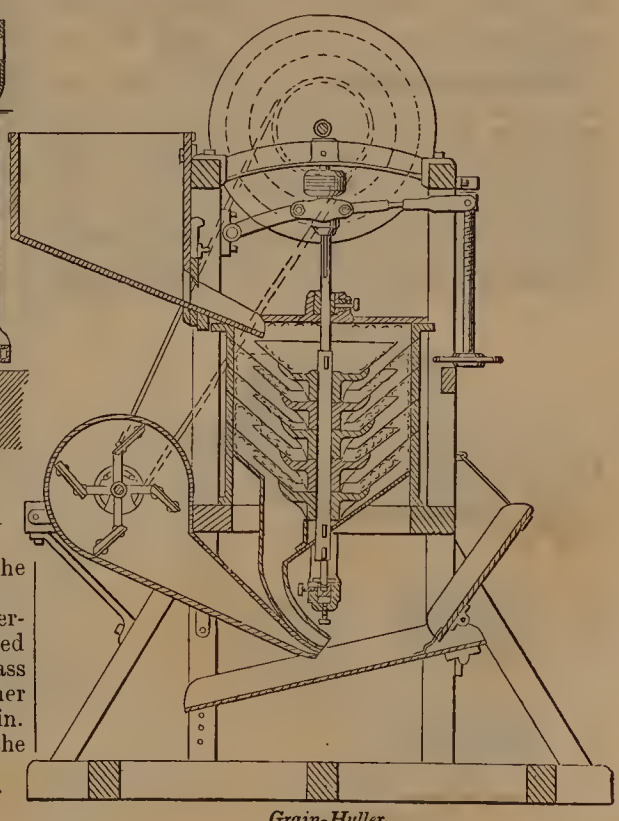
Grain-gage. A device for weighing grain. It has a measure of given capacity, and a scale beam which is graduated to give the weight in pounds and fractions of a measured bushel.

Grain-har'vest-er. A machine for cutting standing grain. There are many varieties, and the idea is as old as the time of Pliny, A. D. 79. In his time the plains of Gaul were reaped by a machine driven by one ox harnessed between shafts. The head of the grain was cut from the straw and fell into a large box which formed a part of the machine. See REAPER; CLOVER-SEED HARVESTER.

Grain-hull'er. A machine for taking the cortex or skin from grain, making hulled wheat, pearl barley, hominy, as the case may be. Known also as a *decorticator*, *debranning-machine*, *hominy-machine*, etc.

Wheat is slightly scalded with steam and then fed

Fig. 2286.



Grain-Huller.

between roughened surfaces in motion, or it is rubbed between stones or disks which are set at such a distance apart as not to grind it. In the example, inclined serrated plates are attached to the case of the machine and intervene between similar plates attached to the vertical revolving shaft. The grain is alternately ejected from the latter and returned by the former, and is thus subjected to the succession of rasping devices, and is eventually discharged at the bottom of the case and cleaned by a blast of air. See COTTON-SEED HULLER; HOMINY-MILL, etc.

Grain'ing. 1. (*Leather Manufacture.*) *a.* The process of rubbing leather with a board to *raise* the *grain*. The leather having been shaved to a thickness at the beam, and daubed, is hung up to dry, and is then folded, grain side in, and rubbed on the flesh side with a *pommel* or *crippler* to give the leather a granular appearance and render it supple. See CRIPPLER.

The hide is then extended and rubbed on the grain side. This is termed *bruising*.

b. A process for giving markings to a surface of leather to imitate the wrinkled appearance of morocco, hog-skin, and some other leathers.

2. (*Painting.*) The imitation of the natural grain of wood by means of tools. Combs, brushes, and the corner of a folded rag, are used in making the various patterns.

3. (*Lithography.*) A mode of giving a certain texture to the face of a stone. One stone is laid upon another with a quantity of sifted sand of a given fineness, and, by a peculiar oscillation and gradual progression, the surface is cut into a set of fine prominences more or less deep and distant, according to the character of the work to be placed upon the stone.

Grain'ing-board. (*Leather Manufacture.*) *a.* A board on which leather is spread while being grained by the *crippler*.

b. A board with a surface impressed or engraved with a pattern, in imitation of the natural grain of some kind of leather, and used to confer the same appearance upon other leather by pressure.

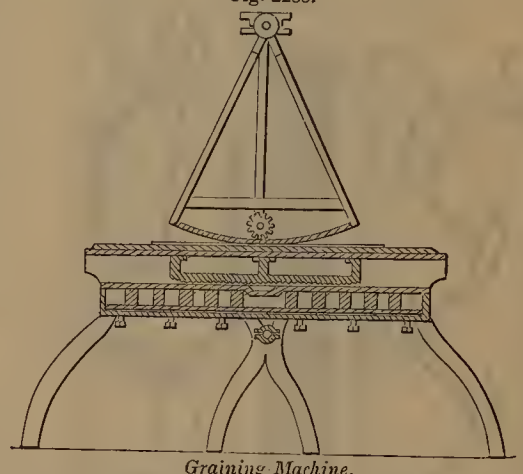
Grain'ing-ma-chine. 1. A roller with a pattern surface representing the grain of wood, and used to transfer the pattern in paint to wood. In the example (Fig. 2287), the roller is an elastic air-bag, which receives its paint from an endless graining-belt.

In the graining-machine for buckets the pail is placed on a block rotated by a winch, and the pattern roller is brought alternately in contact with the pail and inking-roller by the action of a treadle and weighted cord. The surface of the pattern roller is made in removable segments, so that the pattern may be varied in imitation of staves of different woods.

2. (*Leather Manufacture.*) A machine having rollers with raised, parallel, straight, or diagonal threads, which indent the goat or sheep skins and confer the wrinkled appearance to morocco leather.

In the example, the horizontal table vibrates beneath the swinging sector, whose surface has the grained pattern which is to be impressed upon the leather which is between the sector and the table. The graining is sometimes given by hand, by boards or rollers pressed upon the grain side of the leather.

Fig. 2288.



Graining Machine.

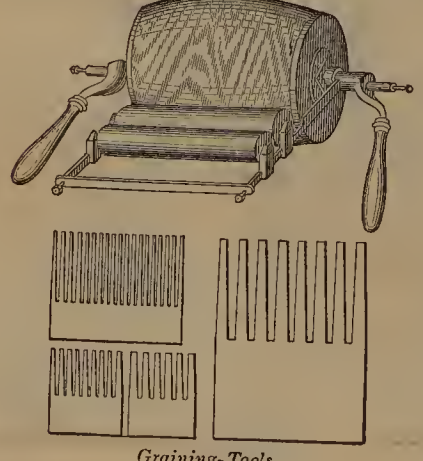
Grain'ing-tool. Hand-tools resembling combs (Fig. 2287), for imitating in painting the lines which represent the growths of timber. A light-colored coat of paint is allowed to dry and a darker coat laid over it. While this is yet damp, it is marked by the graining-tool, which removes some of the darker paint and leaves white stripes behind it. The graining-tools are of steel, horn, wood, or leather, are of different grades of fineness, and have varying numbers of teeth.

Grain-leath'er. 1. Dressed horse-hides.

2. Goat, seal, and other skins blacked on the *grain* side for women's shoes, etc.

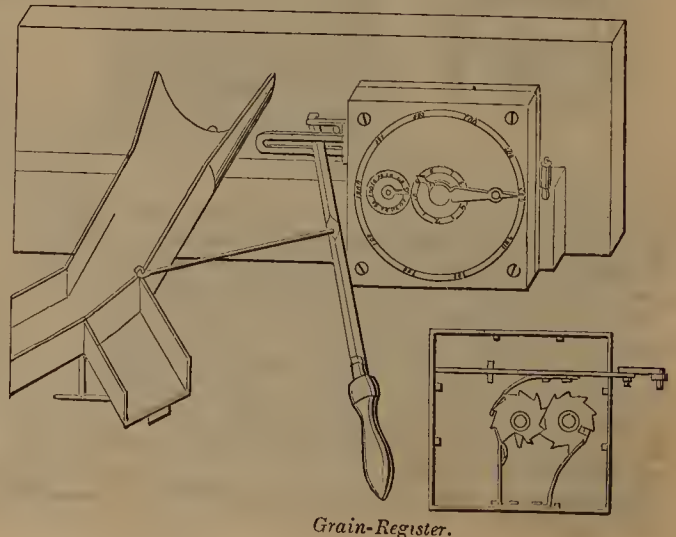
Grain-me'ter. A means for measuring grain,

Fig. 2287.



Graining-Tools.

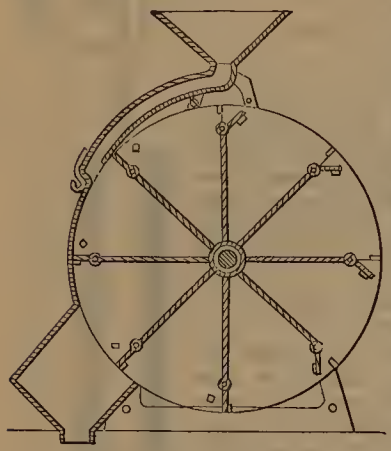
Fig 2289.



Grain-Register.

sometimes by bulk, but more usually in the great grain markets of the United States by weight, as the bushel of grain of a given grade of quality has a legal weight. In the example, a measure is placed under each branch of the chute, and as the gate is moved to direct the grain into either branch the act is denoted by the register, which simply keeps count of the number of motions of the handle. This may be used on thrashing-machines and in filling measures from granaries, but is not so well adapted for the larger needs of the warehouse and elevator. (See ELEVATOR.) In these, a hopper is poised at the end of a graduated beam, weighted for a given number of bushels, say fifty. As the beam rises, the valve at the bottom of the hopper is pulled, the grain discharged, and the process repeated. Automatic registering devices may be used.

Fig. 2290.

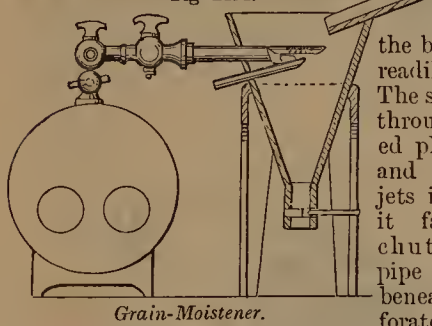


Grain-Meter.

In another form (Fig. 2290) the space between the disks is partitioned by radial divisions into receptacles for grain as it falls from the hopper; the spaces are successively presented for filling and discharging by the revolution of the shaft. The rotations of the wheel are registered by a system of wheels, like the gas-meter.

Grain-moist'en-er. A device for damping the cuticle of grain, in order to enable the bran to be more readily removed. The steam is forced through a perforated plate or shield, and is thrown in jets into wheat as it falls from a chute. A drip-pipe is placed just beneath the perforated shield and carries off the condensed steam.

Fig. 2291.



Grain-Moistener.

Grain-rake. 1. A rake used in raking grain in the swath into gavels for binding.

2. A rake used by one who rides on the reaper in raking gavels from the platform of the machine.

Grains. 1. A residuum of fiber and insoluble matters after infusion or decoction; as the *grains* of malt after the wort is decanted.

2. A harpoon with several barbs. A five-pronged fish-spear.

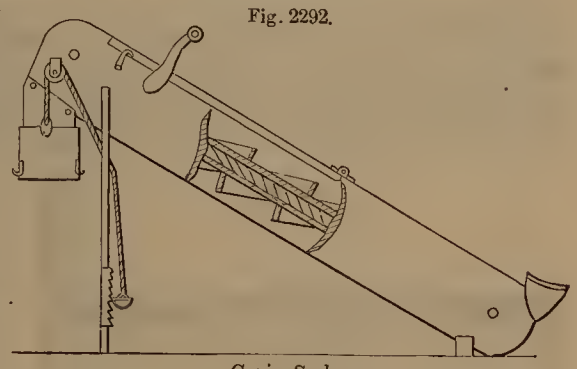
3. Prongs, as of a fish-spear or fork.

4. A *bating* solution of birds' dung, used in destroying the effect of lime, and in improving the flexibility of leather.

5. Pieces of sheet-metal, cast-iron, or tinned iron inserted into a mold for the purpose of supporting an accessory portion, such as a *core*, in position.

Grain-sack'er. A device for sacking grain. In the example, the grain is raised by an endless apron and buckets, and is discharged through an adjustable tube, to which bag hooks are attached. See BAG-HOLDER.

Fig. 2292.

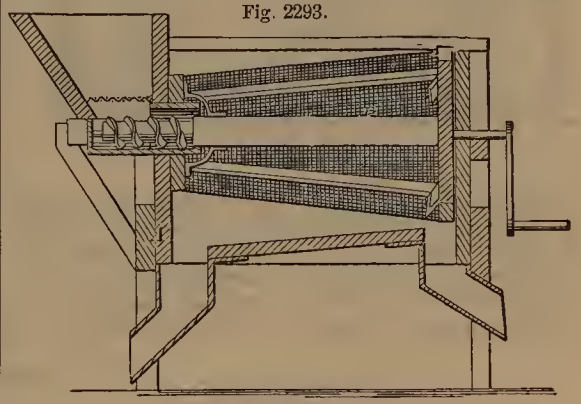


Grain-Sacker.

Grain-scour'er. A machine for cleaning grain. A *smut*-mill. A machine in which grain is rubbed and chafed, and eventually sorted into qualities by gravity and blast.

Grain-screen. A shaking sieve, or a rotating cylindrical reel of wire-cloth in which grain is sorted by quality, according to its ability to pass through the meshes of the sieve. The grain-screen is a part of every fanning-mill: it is also used in the *separator*, which is a thrasher and cleaner. It is also used as a means of cleaning grain from cockle, cheat, grass-seeds, and dust; especially wheat for seed.

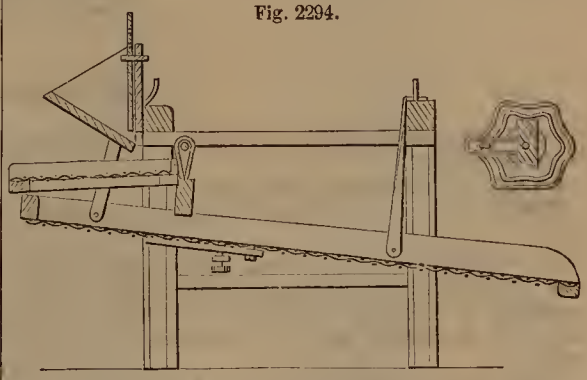
Fig. 2293.



Grain-Screen.

Fig. 2294 shows a reciprocating form of the device; the riddle and screen are suspended upon adjustable straps and have a very rapid motion communicated by means of a cam-wheel and lever. The riddle is agitated in the opposite direction to the screen.

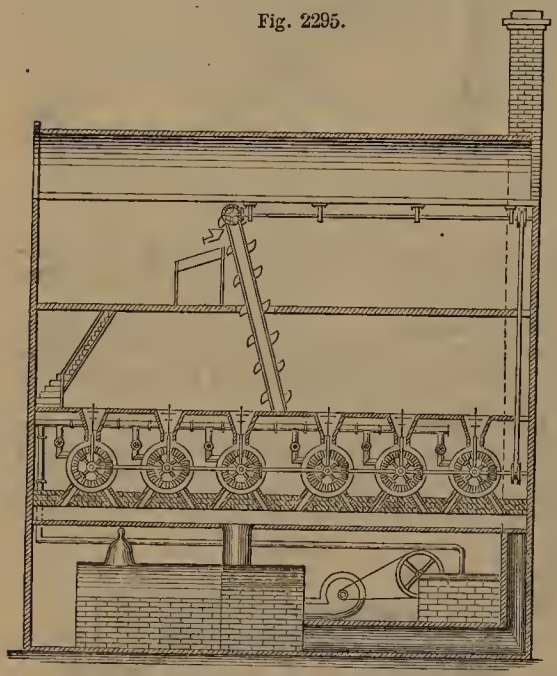
Fig. 2294.



Grain-Screen.

Grains-dry'er. An apparatus for drying the spent malt, known as brewer's *grains*, or other similarly sodden material. The illustration shows a regular plant for this purpose, consisting of a series of six cylindrical casings, with rotating paddle-shafts driven by bevel-gearing from a single shaft rotated

Fig. 2295.



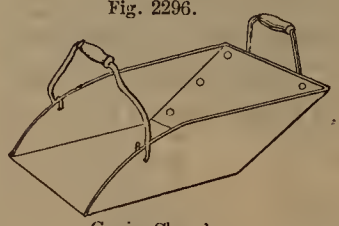
Grains-Dryer.

by power from the engine. The casings are heated by steam-pipes, and the grains pass into one end of the cylinder and out at the other, being then elevated to the upper floor, where they are sacked. Grains are dried for feed, spent hops for manure, sprouted grains for malt. A fan drives furnace-heated air through the grains, the hot vapor passing out at the upper part of the cylinder.

Grain-sep'a-ra'tor. A thrashing-machine. See SEPARATOR; THRASHING-MACHINE; GRAIN-SCREEN; FANNING-MILL.

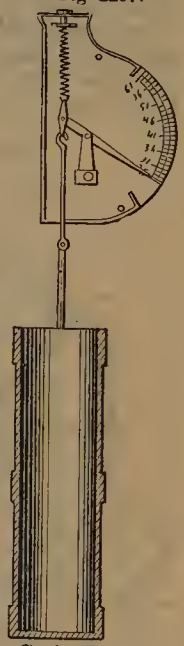
Grain-shov'el. One for handling grain in bag-

Fig. 2296.



Grain-Shovel.

Fig 2297.



Grain-Tester.

ging, on the floor of a kiln, granary, or warehouse, or in the hold of a vessel where it is in bulk. In the example, the swinging handles are attached in positions to bring the weight of grain evenly on both hands to facilitate the shoveling of the same.

In the more usual form it is a scoop-shaped shovel.

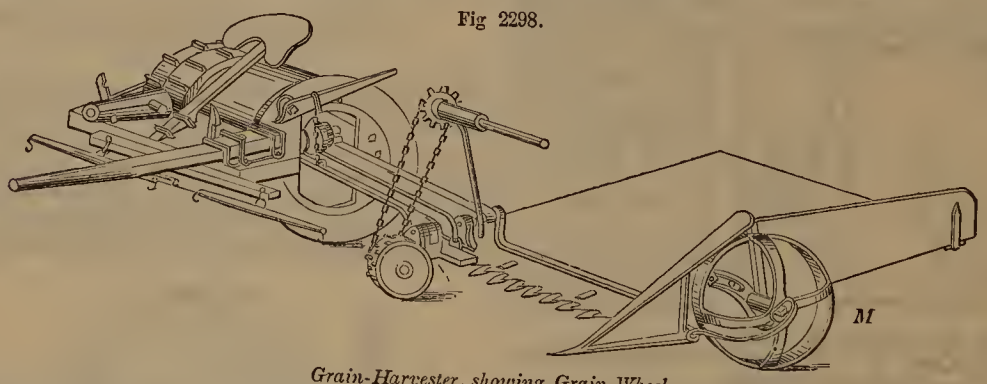
Grain-test'er. A means for weighing small quantities, as samples of grain. The cup has a known capacity, as a certain aliquot part of a bushel, and the divisions on the scale indicate the pounds which a bushel of the grain tested would weigh.

Grain-thrash'er. A machine for operating on grain in the sheaf to remove it from the straw. See THRASHING-MACHINE.

Grain-tin. Crystalline tin ore. Metallic tin smelted with charcoal. Tin reduced from the loose grains of tin stone.

Grain-wheel. (*Husbandry.*) The wheel *M* of

Fig 2298.



Grain-Harvester, showing Grain-Wheel.

a harvesting-machine which supports the outer end of the finger-bar.

Graip. A manure or potato fork.

Gran'a-ry. A bin or house for storing thrashed grain.

In the cradle of civilization, Egypt, the granaries were on a costly and unsurpassed scale. They consisted of buildings in which the bins were arranged in a double row of brick structures, like ovens.

These were probably of adobe, and had two doors; an upper one through which they were filled, and a lower one through which the grain was removed. They were ascended by steps, as shown in the illustration, which is from a painting in the tomb of Rotei at Beni Hassan. The grain is measured and noted by attendant clerks, as shown in another painting.

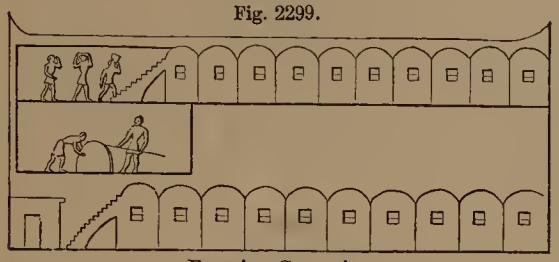
Demosthenes tells us that, of the whole foreign importation of grain into Attica, one half came from the Scythians of the Euxine, and estimates its amount in ordinary years at 400,000 medimni = 600,000 bushels. The fertility of the soil and the habits of the people remain nearly the same, and the trade of England with Odessa, at the present time, is a counterpart of that which twenty-three centuries ago was carried on between Athens and the Scyths of the Pontus.

"The Greeks in former times [STRABO, A. D. 16] imported from the Chersonesus corn and the cured

fish of Palus Mæotus. Leucon is said to have sent to the Athenians 2,100,000 medimni of grain from Theodosia (a town)." A medimnus was about 1½ bushels, English.

A Sicilian bushel of wheat in the time of Polybius (150 B. C.) was worth, in Cisalpine Gaul,

Fig. 2299.



Egyptian Granaries.

Lombardy, and Piedmont, 4 oboli per bushel, barley 2 oboli. The obolus was about 3 cents.

The tavern price there for a good meal was ½ obolus.

The granaries of the Romans were of several kinds, and were enumerated at 327. One kind was a building with heavy brick walls, and a hole in the roof through which it was filled. Another was a structure raised on wooden columns.

In Thrace, Cappadocia, Spain, and Africa, grain was laid up in pits lined with chaff. Caverns and cisterns were used in Palestine. A similar practice yet prevails in Tuscany.

Grand-ac'tion. A piano-forte action, in which three features are combined: 1, a *hammer* to strike the string; 2, a *hopper* to elevate the hammer, and then escaping therefrom leave the latter instantly to fall away from the string, independently of the position of the key; and 3, a *check* to catch the hammer and prevent rebounding.

Grande. (*Sugar Manufacture.*) The largest evaporating-pan of a battery.

Grand-pi-a'no. A harp-shaped piano, whose form is suggested by the varying lengths of the strings, the mechanism being introduced in the most effective manner regardless of the dimensions of the instrument, as in the square or cottage, where the motions are incommoded to bring the instrument within certain limits or proportions. See PIANO-FORTE.

Certain piano-forte movements are invented for and known as grand-actions.

The grand-piano has three strings to each note.

The *bi-chord* or *semi-grand* has but two strings to a note, but has the *grand* movement. The *cottage* or *boudoir* grand has shorter strings, and is less bulky.

The *grand square* has the movement of the grand in a square case.

The *upright* grand was set on end, and, being unwieldy, was superseded by the *cabinet*, in which the frame came down to the floor, long vertical rods transmitting the movement of the keys to the upper ends of the wires.

Gran'ite. A hard and durable silicious stone composed of quartz, feldspar, and mica conglomerated.

Gneiss has similar components, but is stratified.

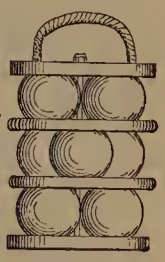
Gran'ite-axe. (*Quarrying.*) A stone axe for spalling granite.

Gran'ny's Knot. (*Nautical.*) A knot in which the second tie is across, differing from a reef-knot, in which the end and outer part are in line. See KNOT.

Gran'u-la'ted-steel. (*Metallurgy.*) Melted pig-iron is scattered by a wheel into a cistern of water, and thus reduced to fragments. These are imbedded in powdered hematite or sparry iron ore, and subjected to furnace heat. The exterior of the fragments become decarbonized, and thus reduced to the condition of malleable iron. The metal is made homogeneous by melting, and steel is produced.

Grape-shot. Spherical iron shot rather less than half the diameter of the bore of the piece for which they are intended, and put up in *stands* consisting of three tiers of three shot each; the stand has a circular cast-iron plate at top and bottom connected by a bolt and nut; two rings bind the tires together and keep them in place. Grape-shot are now little used, except with guns of the larger calibers, from 24-pounders upwards.

Fig. 2300.



Grape-Shot.

Quilted grape are formed by sewing the shot up in a sort of canvas bag, which is afterwards wrapped around with twine or cord, so as to form meshes; musket bullets put up in this way were formerly employed for blunderbusses, wall-pieces, and small artillery.

Grape-trel'lis. A structure on which grape-vines are trained. See TRELLIS.

Previous to 1547 (time of Edward VI.) grapes were brought from Flanders to England. The vine was introduced into England in 1552. The statements of the growth of the vine in Britain (time of Julius Cæsar) seem to lack confirmation. One of the largest vines in Europe is that of Hampton Court Palace, near London, the famous palace built by Cardinal Wolsey and given to Henry VIII. It is stated to have been planted in 1769, and to have produced 2,272 bunches of grapes in a season, weighing over 2,000 pounds; its stem being thirteen inches in girth.

Graph. Names ending in "graph" are as follows. The list is given for the convenience of those in search of a word: —

Actinograph.
Anaglyptograph.
Anemograph.
Arcograph.
Auto-chronograph.
Auto-typograph.
Barograph.
Barometrograph.
Catagraph.
Cecograph.
Cerograph.
Chalcograph.
Chorograph.
Chromo-lithograph.
Chronograph.
Crytograph.
Curvograph.
Cyclograph.
Ectotypograph.
Eidograph.
Electro-chronograph.
Ellipsograph.
Embossed typograph.
Galvanograph.
Glyphograph.
Glyptograph.
Helicograph.
Heliograph.
Hyalograph.
Hydro-metrograph.
Hyetograph.
Hygrograph.
Ichnograph.
Kinograph.
Lithograph.
Magnetograph.
Marigraph.
Mechanograph.
Metallograph.
Metrograph.
Micrograph.
Noctograph.
Odontograph.
Omnigraph.
Optigraph.
Orthograph.
Paneiconograph.
Pantelegraph.
Pantograph.
Perspectograph.
Phonautograph.
Photogalvanograph.
Photograph.
Photo-lithograph.
Photo-metallograph.
Photo-zincograph.
Pianograph.
Polygraph.
Scenograph.
Sciograph.
Scotograph.
Seismograph.
Sologragh.
Sphercograph.

Sphygmograph.
Stereograph.
Teleioconograph.
Thermetrograph.
Thermograph.
Vitreograph.
Xylograph.
Xylopyrograph.
Zincograph.
See also METER; SCOPE; TYPE.

Graph'ic-mi'cro-scope. A microscope provided with a reflector, which casts down the image upon a sheet of paper. The instrument has two reflectors, the second one of which is a prism, across the edge of which the eye observes the image, which may be traced by a pencil.

Graph'ite. A form of carbon occurring in nodules or foliated six-sided prisms, and used for pencils, for blacking stoves, for crucibles, and for lubricating. Graphite was supposed by the early chemists to be a carburet of iron, but it is now universally acknowledged that iron is only mechanically mixed with it, there being no chemical combination between them. It may have a trace of iron, but this is not essential. Its name, *graphite*, is derived from its use in writing and drawing. It is well known in the mechanic arts as *plumbago* and as *black-lead*, but the names have no relevance, as *plumbum*, lead, is not found in it.

It is a unique mineral, useful for many and widely different purposes in the mechanic arts. It was utilized as a lubricator in the immediate neighborhood of its natural deposits two hundred years ago, but was not widely used till within the past few years. It can hardly be exceeded as a lubricator, when finely pulverized, perfectly pure, and free from grit, — conditions which are absolutely necessary for this use. It has been mixed with clay for crucibles since the tenth century, but was not generally adopted till the foliated variety was utilized, in 1827, by an American, — the late Mr. Joseph Dixon of Jersey City. It was early adopted for crayons, and was found in use by the Aztecs when Cortez landed in Mexico. It is indispensable in the graphic arts, in the form of what are commonly called *lead-pencils*, the finest of which were formerly made in England from the granulated, pure graphite, taken from the celebrated Borrowdale Mine in Cumberland; but after that mine became exhausted the world was supplied with pencils made from the impure graphite found in Bavaria and Bohemia, purified for the purpose. Bavaria is well represented by the Messrs. Faber, whose pencils of all qualities are so well known. But recently the fine graphite found at Ticonderoga, in the State of New York, has been utilized for this purpose by the Dixon Crucible Company of Jersey City, and a fine quality of pencils produced, — the company having been awarded the Medal of Progress for them by the Vienna Universal Exposition, 1873.

Graphite is polymorphous, has a bright metallic luster, of a steel-gray color, something like that of molybdena, but darker, and the two are sometimes confounded by inexpert persons, both being sometimes formed in flexible laminæ; but the molybdena has none of the physical characteristics even of foliated graphite, except the similarity of color and form.

Molybdena has a sp. gr. of about 4, which is about double that of graphite. Nitric acid attacks molybdena, reducing it to a yellow powder, but does not affect graphite. Molybdena gives a yellowish green flame with the blow-pipe; graphite does not. Graphite in the blow-pipe flame burns away to carbonic acid, leaving but little ash, and, if pure, develops no odor. Molybdena deflagrates with niter much more violently than graphite. The formation of graphite most common in the pure state is that of laminated crystals, elongated at right angles with the sides of the vein, if not more than from four to six inches wide; but when the vein widens, the crystallization often radiates from numerous centers, and the whole formation is very beautiful; the foliated variety is equally valuable and more brilliant, but rare in any quantity; the acicular form of crystal is not apt to be as pure in the lump, but is useful for most purposes; the granulated variety, the purest of all, is of little use for crucibles, but, with suitable manipulation, produces the finest grades for electrotyping and fine lead-pencils, and is unequaled for lubricating. Pure graphite is absolutely free from grit, when pulverized and rubbed between the fingers, and the polish produced in the same way is instantaneous and very bright, being like a darker shade of polished silver. It is also found mixed with iron, rhombspar, and other forms of lime, the rock and earth in which the vein is carried, and many other foreign substances injurious for all the purposes for which pure graphite is needed. Lime, for instance, is fatal to graphite for crucible making.

It is very refractory in closed vessels, but combustible in air or oxygen at a high heat. It is infusible. The laminated and foliated varieties are difficult to pulverize, reducing to scales instead of grains, and if it is wanted very finely divided must be ground in water.

It is found in these varieties mainly in Ceylon, where it occurs in veins, carried in rock and kaolin; the lumps are removed and sent to market as they are, not being entirely pure, but sufficiently so for most purposes. It is found in many of our own States and in Canada, in veins and disseminated in quartz and other rock, from which it is separated by stamping in water and floating off the scales; but while this process, with care in the manipulation, produces the purest graphite for use in the arts, it has not so far been successful except at Ticonderoga, by the American Graphite Company. A large deposit of the granulated graphite was supposed to have been found in California, and a favorable report was made upon it by one of the European savants, but there is no real graphite in the mixture; it is a sort of carboniferous clay, deceptive in its physical characteristics. A good, compact, granulated graphite is found in Sonora, Mexico, and a specimen brought to us from Japan is of the same character; but the granulated graphite best and longest known to commerce is found in vast quantities in Bohemia and Bavaria. It is divided in water and floated, to separate it into grades, not being pure enough as it comes from the mines. It is cheap in price, but poor in quality for use in the arts, except for pencils after extensive purification. It is not very refractory, and is of but little use for crucibles, although long employed for want of better. It is useless for polishing, or for preservative paint, or for lubricating, and, having a very low conducting power, cannot be used to advantage for galvanoplastics. It resembles a weak, black clay in appearance, and has but two of the physical characteristics of true, natural graphite, these being the marking and the greasy feel when highly purified. There are large deposits of compact granulated graphite in Siberia, but they are so far from any means of transportation that only the deposit discovered by Mr. Alberti has as yet been made use of, and that is under contract to the Messrs. Faber of Stein, Bavaria, for pencils.

Natural graphite has a sp. gr. of 2.089 – 2.245. Artificial graphite forms on the inside of furnaces

and retorts where coal is used for making gas; but it is so hard and harsh that it is not adapted to many uses, and has been utilized only for carbons for galvanic batteries by sawing it into the required shape. Graphite occurs in the primitive and frequently in the transition rocks, in granite, gneiss, quartz, feldspar, kaolin, mica-slate, schist, crystalline limestone, and occasionally in the coal formations. It is generally in veins, but in the quartz it is often in disseminated scales. In Ceylon it is in well-defined veins. In the United States and Canada it occurs in irregular veins and in nests, patches, and pockets, the only reliable veins known being those of the American Graphite Company at Ticonderoga, New York.

Graphite is the purest carbon next to the diamond, but requiring a higher heat to burn it, and leaving a reddish ash if the specimen contains a trace of iron, as most of it does. It is not affected by acids or alkalies. If the well-known process of washing is not sufficient to purify the graphite to the required degree, then either of the following methods may be adopted.

Method of Professor Kerl of the Royal School of Mines, Berlin. Heating to a red heat in a retort will change the iron oxide into metallic iron, and sulphate salts into sulphides of metals, for the extraction of which employ hydrochloric acid.

Professor Loewe heats the graphite to a red heat, with double the quantity of carbonate of potash, soda, or hydrate of potash; he extracts the formed potash salts, especially the silicate of potash, with boiling water, heats the residue gently with dilute nitric or strong hydrochloric acid, filters, and washes out with water and dries. Repeating this process three times yielded an entirely pure graphite.

Professor Brodie obtains a graphite almost pure, 99.96 carbon, by boiling graphite with acid, and heating with hydrate of potash. If the graphite is pulverized, mix it with ¼ of its weight of chlorate of potash, and double the weight of the graphite of concentrated sulphuric acid; heat the mixture in a water-bath; a little fluoride of sodium is added to remove silica, and the whole carefully washed, dried, and heated to a red heat.

Graphite may also be purified sufficiently for most uses by treating it with 4 parts sulphuric and 1 part nitric acid, washing and drying. See CRUCIBLE; PENCIL.

These points are taken from the manuscript of a work on graphite, now in course of preparation, by Orestes Cleveland, President of the Dixon Crucible Company, of Jersey City.

Graph-om'e-ter. A surveying instrument for taking angles. A *demicircle*.

Graph'o-type. A process invented by Hitchcock, in which a zinc plate is covered with a thick coating of oxide of zinc, placed under an hydraulic press to made a perfectly plain and hard surface, the design drawn upon the oxide with an ink consisting of a chloride of zinc and a menstruum. This produces as to the parts where the ink touches a very hard material, the oxychloride of zinc. The remaining surface is rubbed away by brushes, velvet, and the fingers, leaving the lines in relief to be printed from.

The process is more used in England than in this country, though it is an American invention. The English illustrated paper, the "Graphic," is understood to be largely illustrated by this means.

In one form of the process the adhering material is solidified by immersing it in a solution of silicate of soda.

Grap'nalls. A heavy tongs used for dragging logs, chunks, stones, etc. See GRAPPLE.

Grap'nel. 1. A small anchor having five or six hooks arranged in a circular manner on the end of the shank, which terminates in a ring to which the cable is attached. It is used by small vessels and boats, and sometimes as a kedge in warping or hauling.

Fig. 2301.

Grapnel.

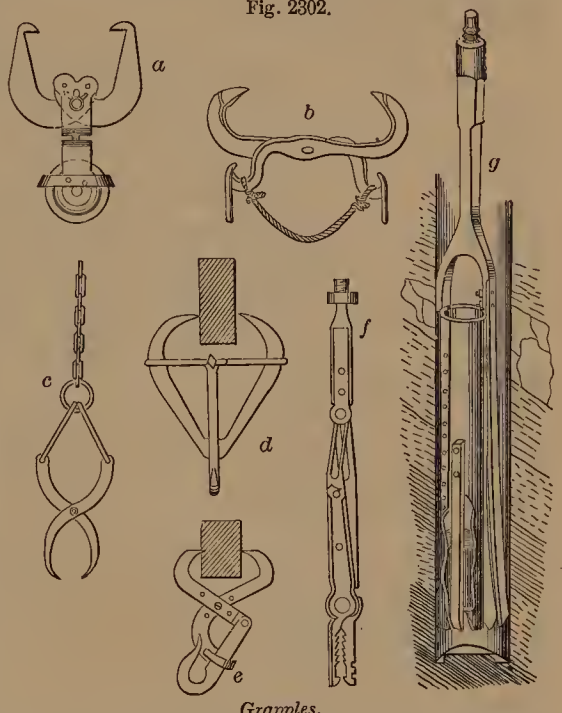
2. An implement for recovering tools, etc., dropped into a bored shaft; or for breaking and raising the axial stem left by the annular borer. See GRAB; GRAPPLE.

Grap'ple. 1. A hook for securing one vessel to another or one object to another. Used in holding vessels in engagement while boarding, or in a more peaceable way to hold them associated while loading, unloading, or transferring cargo. A *grappling-iron*.

2. A grasping tongs, used in various shapes and for many purposes.

a is a form used to grasp on each side of a rafter or beam to form a means of suspending hay-hoisting

Fig. 2302.



Grapples.

tackle. The claws form a toggle which is clasped against the wood by the weight suspended from the sheave.

b is somewhat similar, the claws being moved in by the weight suspended from the bight of the cord.

c is for ice-tongs or clutching other objects to be lifted.

d has a pair of toggle-bars jointed to the claws.

e is a toggle-clutch.

f has claw-ended levers for reaching tools dropped into or broken in bored wells.

g is a *grab* for recovering well-tubes from bored wells or shafts.

Grass-cloth. A light fabric resembling linen, exported from the Malay Islands. It is made from the fiber of the "poa," a species of nettle.

A similar cloth is made from the Chinese *ma*, a species of *cannabis* (hemp). It is perennial, and sends up numerous stems of from 7 to 10 feet in hight.

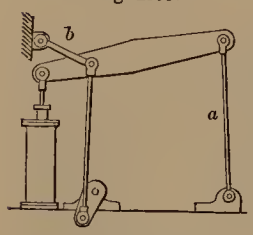
The plant yields three crops every year. The first cutting takes place in June. On being cut, the leaves are carefully taken off with a bamboo knife by women and children, generally on the spot. It is then taken to the house and soaked in water for an hour. In cold weather the water should be tepid. After this the plant is broken in the middle, by which the fibrous portion is loosened and raised from the stalk; into the interstice thus made, the operator, generally a woman or child, thrusts the finger-nails and separates the fibers from the center to one extremity and then to the other. A partial bleaching is effected on the fibers before they undergo farther division, sometimes by boiling and at other times by pounding on a plank with a mallet. After being dried in the sun, a tedious process of splitting the fibers by the finger-nail ensues, then hatcheling, followed by rolling in balls, soaking, washing, and steeping in lye. The fibers are then spliced for the weaver.

Grass-edg'ing Shears. A form of large scissors with a bent shank, and used for cutting the straggling leaves of grass at the edges of grass-plots and of grass-bordered beds.

Grass-har'vest-er. See MOWER.

Grass'hop-per-beam. One form of working-beam used in steam-engines. Instead of oscillating in fixed bearings, one end is attached to a rocking pillar *a*, and the point of attachment of the pitman to the beam bears such relation to that of the piston-rod as will correspond to the relation between the stroke of the piston and the throw of the crank. *b* is the radius-bar of the parallel motion which secures verticality to the piston-rod.

Fig. 2303.



Grasshopper-Beam.

Grass'ing. The exposure of *steeped* flax-straw on the grass, where it is spread evenly and frequently turned to wash out the mucilage and loosen the *shives* and *boon*. Then follows *breaking*.

Grass-seed Sep'a-ra'tor. A form of sifter by which grass-seed is rid of larger and smaller matters, either grains or weed seeds, as the case may be. It may have several sieves, with wire-cloth of varying fineness, the more open to allow the grass-seed to pass and remove larger matters, and sieves with closer meshes to hold the grass-seed and allow certain small weed-seeds and dust to pass.

Grate. 1. A grated box or basket, or a box with a series of bars for a floor, in which fuel is burned.

The oldest form of grate may have been a row of bars laid upon bearers or stones so as to admit air beneath the fuel in the intervals of the bars. A *cresset* or *fire-cage* is also an old form of grate. See CRESSET.

In an inventory, dated 1606, of the goods of Sir Thomas Kytson, at Hengrave Hall, Suffolk, England, mention is made of "a cradell of iron for the chimnye to burn sea-coal with," and also "j fier sholve made like a grate to seft the sea-coal with." The "cradell" was probably a standing basket-grate. This is an early mention of the use of sea-coal, but the basket form was common in cressets.

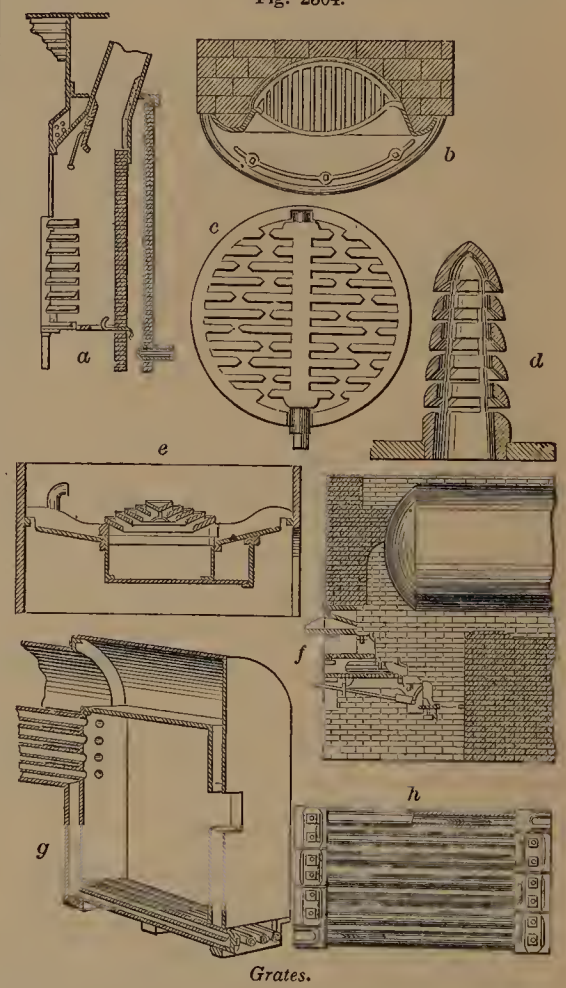
James Watt, in 1785, patented an arrangement for consuming the smoke in furnaces, by supplying the fire from above downward by means of a reservoir of fuel in contact with the ignited mass, the fuel descending by its own weight to supply the consumption.

Combustion was supported by a strong lateral current of air passing through the fire to a flue on the other side, near the entrance of which was a supplementary fire which consumed the smoke of the first.

Cutler patented a smoke-consuming contrivance for open fires in 1816, and in 1817 Deakin attached a metallic box, holding fuel for one day's consumption, to the back of the fireplace; the fuel was drawn forward horizontally by a screw, as required, and in this way the smoke was nearly all consumed.

In the same year Hawkins patented a shovel for supplying coal to the fire at bottom. The shovel

Fig. 2304.



Grates.

had a cover, and the contained coal was pushed forward into the fire by a piston.

The revolving grate was introduced by Steel and Brunton, English patents, about 1819.

Grate-bars of hollow tubes, connecting water-boxes at front and rear, were introduced by Chapman in 1824. See SMOKE-CONSUMING FURNACE.

In 1825, Atkins attached a fuel-chamber to the back grates, the bottom of the chamber being made to slope at a considerable angle.

Jeakes, in 1854, formed a movable grate, which was lowered into the fuel-box, gradually consuming

the fuel and admitting a supply of air from above to support the combustion.

Rowe, in 1854, introduced coal into the bottom of the grate by a pipe leading from a side reservoir of fuel.

In 1854, Bachhoffner consumed the smoke of one fire by passing it through an upper fire.

Leighton, in 1856, surrounded the sides and back of a fire-grate with a fuel-chamber, the fuel being brought forward by a poker, as required. The outer coal is thus coked. See also FIREPLACE.

Grates are known by many names indicative of position, as *low-down;* purpose, as *steam-furnace* grate; construction, as *revolving, shaking,* etc. Fig. 2304 shows some forms, in which —

a is the ordinary basket-grate of the parlor fireplace.

b is the low-down grate as viewed from above, the wall in section.

c is a stove-grate, in which the central oscillating portion has alternately long and short bars, which act in conjunction with others projecting inward from the ring, the ends of each being deeper as more exposed to wear.

d is a cone-shaped or pyramidal grate opened at its bottom, intended to be placed in the center of a fire-pot in a stove. The bars of these grates are inclined downwards from the center to the outside, so as to prevent the fire-coal, sawdust, tan, etc., which it is intended to burn, from choking up the apertures in the grate.

e is Eaton's locomotive furnace-grate. The congeries of grate-bars are in steps, and afford more uniform access of air to the fuel. The ash-pan has back and front dampers, and a perforated guard-plate in front to govern the draft.

f is composed of three or more tiers, in combination with a fire-box and trap-grate. When in use, a continuous inclined plane of incandescent coals is formed from the upper tier to the lowest grate.

g is a steam-boiler furnace. The grates are tubular, and have longitudinal horizontal diaphragms extending nearly throughout their length, forming an extension of the boiler-surface in which the water circulates.

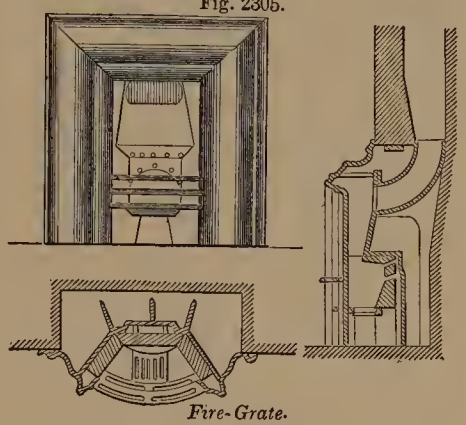
In *h* the tubes are combined into a continuous passage for the water, the alternate ends being connected by caps which admit of expansion.

The commission appointed by the House of Commons in 1856 to examine into the best mode of heating buildings reported a fire-grate for heating barracks, hospitals, etc., which embodies many of the best features of previously existing inventions.

Fig. 2305 illustrates a grate of this kind set in an ordinary fireplace. The grate is placed as much forward in the room as possible; the part in which the fire is contained is of fire-brick; the bottom, being partly solid, checks the consumption of fuel. A supply of air is admitted from behind the grate, and is thrown on the top of the fire to assist in consuming the smoke; the sides are splayed so as to throw the heat by radiation as much as possible into the room; the opening into the chimney has no register; there is a chamber behind the grate into which air is brought from the outside and warmed by the large heating surface of the back of the grate, increased by flanges, and after being heated to from 56° to 70° F., the air passes into the room by a shaft cut out of the wall which terminates in a louvered opening placed out of reach, or a shaft of sheet-iron may be fixed to the wall to serve the same purpose. In the accompanying plan and section, the fire-brick lining of the grate is shown by the shaded portion; the back lining has grooves in it terminating in holes just at the bottom of the splay, which form air-channels for admitting air at the back over the fire. The hearth is made of a plate of cast-iron.

The contrivance for admitting air into the air-chamber depends on circumstances. If the fireplace be built in an external wall, the openings for fresh air may be made in the back; but if in an internal wall, the channel from the outside may be either between the flooring of the room and the ceiling joists of the room below, or in the spaces between the joists, or by a tube or hollow beam carried below the ceiling of the room below.

Fig. 2305.



Fire-Grate.

The subject may be pursued under a variety of heads, where allusion may be found to heating and ventilating devices. See FURNACE; VENTILATOR, etc. Also specific indexes under AIR-APPLIANCES; STOVES AND HEATING-APPLIANCES, etc.

2. (*Mining.*) A metallic perforated plate on which ores are stamped.

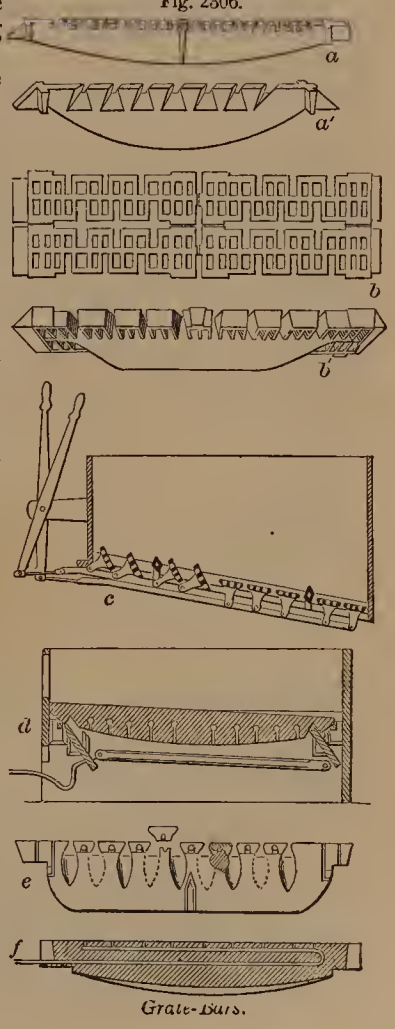
Grate-bar. The iron bar in a furnace which supports the fuel. A part of a grid in a furnace.

Among the numerous forms may be cited: —

a a', the *paragon*-bar, which has passages for air formed by notches in the upper surface expanded downwardly, so as not to fill with ashes.

b b' are two views of a grate-bar. The upper view is a top view of two bars; the lower one

Fig. 2306.



Grate-Bars.

shows a side and bottom view, with a strengthening belly flange.

c is an inclined shaking grate composed of a number of bars, with lozenge-shaped openings, cast in one piece, and so arranged as to be operated in pairs or all at once, by levers. The bars are placed at right angles with the length of the grate; the air supplied to them from beneath flows through their perforated tops, which rise above the surface of the grate, and among the burning coals.

In *d* each alternate bar is supported by the imposition of its inclined edge upon the oblique surface of the cross-bars at either end. When the rock bars are moved, they strike against the notches and cause one end of the grate-bar to climb upon the supporting bar, while the other end slides down the incline of the supporting bar at that end.

e has spaces between the fuel points which admit air to the incandescent fuel, and afford an escape for dust and ashes from the fire-bed. Provision is made for economically renewing the fuel points, and the construction is such as to afford a proper grate surface, with a copious supply of air.

f has a steam-pipe passing longitudinally through the grate-bar and throwing jets of steam from its upper surface.

These are but a few of the numerous kinds.

The grate surface should be equal to one square foot for each horse-power.

Grat'er. 1. A plate roughened by punching holes which raise protuberances forming a rasping surface. Used for grating ginger, nutmeg, horse-radish, lemons, crackers, etc.

2. (*Bookbinding.*) An iron instrument used by the forwarder in rubbing the backs of sewed books after pasting.

Grate-sur'face. (*Steam-engine.*) The area of surface of grate by which air has access to the fuel.

In an average boiler this is 1 square foot per horse-power, and is expected to evaporate 1 cubic foot of water per hour.

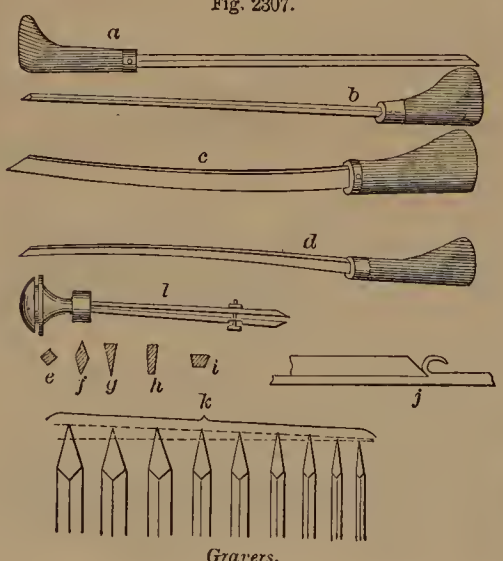
With the Cornish boiler double this amount of grate-surface is allowed. With the locomotive, 1 square foot evaporates 8 cubic feet of water.

Grat'ing. (*Nautical.*) An open wood-work of cross slats to cover hatchways and yet admit light and air.

Grav'el-car. A railway ballast-wagon.

Grav'er. Gravers are used for engraving or chasing metals or other materials, such as fine hard woods, in certain descriptions of ornamental work. They are made of fine steel, which, for cutting steel, is tempered to a "pale straw" color, the first color that appears in "drawing the temper."

Fig. 2307.



Gravers.

Gravers are made of different shapes. Those for "line" engraving are square or rhomboidal in their cross section, and the end is sharpened by grinding it off obliquely, as seen in the figures *a b c*. The lower edge of the graver is termed the *belly*, and is angular for line-engraving. For engraving lettering it is frequently rounded or flat, and for heavy work is destitute of a handle, and is driven by a hammer.

d shows the shape of the graver used in *stipple* or *chalk* engraving, so called from its consisting of dots which resemble the appearance of chalk-drawing upon rough paper. See STIPPLE-ENGRAVING.

e is a section of a square graver.

f is a lozenge graver.

g h i are tint tools, used principally by wood engravers.

j shows the work of a tint tool.

k shows a set of tint tools.

l is an adjustable double graver.

Grave'stone. A monumental stone for erection or erected at a grave. The advertisement by the Quartermaster-General, U. S. A., for bids for furnishing 300,000 gravestones for soldiers' graves at different national cemeteries throughout the country, brought forward specimens of all materials, — white and black marble, polished and plain, sandstone of various colors, white and red clay, vitrified and unvitrified, porcelain, eryolite porcelain, béton-coignet, and all sorts of composite stone; painted iron, malleable iron, compositions of tin and spelter, copper and spelter, brass, bronze, and wood.

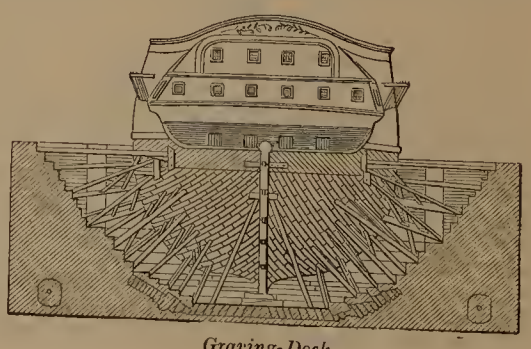
One stone from Philadelphia has letters cut by a *sand-blast* system in seven minutes.

Grav-im'e-ter. An instrument for determining the specific gravities of bodies. Nicholson's instrument consists of a hollow ball of brass or copper, having a stem rising from its top which supports a cup or dish. Another dish is suspended from the lower part of the ball by means of a stirrup; this dish is made heavy enough to keep the instrument vertical when placed in a liquid; and the weight of the instrument is such that 1,000 grains placed in the upper dish sinks it in distilled water, so that a mark about the middle of the stem is on a level with the surface of the liquid. See AREOMETER.

Grav'ing. (*Nautical.*) Cleaning a ship's bottom by burning off the sea-weed and then paying the planks with pitch. Ships were formerly beached for this purpose, and the work was done during the recess of the tide. It is also called *beaming*. See GRAVING-DOCK.

Grav'ing-dock. A dock into which vessels are floated to have their bottoms examined and cleaned. A *dry-dock*.

Fig. 2308.



Graving-Dock.

The vessel is floated in and the gates at the entrance closed when the tide is at ebb. The remaining water is then pumped out.

The graving-dock of the Navy Yard at Brooklyn measures 350 feet in length within the caisson-groove, and the main chamber is 98 feet in breadth at the top. The width of entrance is 68 feet, and the depth of water 26 feet. It was commenced in 1841, and completed in 1851. Great difficulty was experienced in its execution, occasioned mainly by the softness of the foundations; upwards of 8,000 piles, varying from 25 to 40 feet in length, having been employed in the work, which is stated to have cost $2,000,000. It is built of granite, and is furnished with iron gates and an iron caisson or floating gate.

Other larger ones are now constructed at South Brooklyn.

Many of the Liverpool docks have graving-docks, and some of the dock-entrances are arranged to be used as graving-docks. Two of the latter have the following dimensions: —

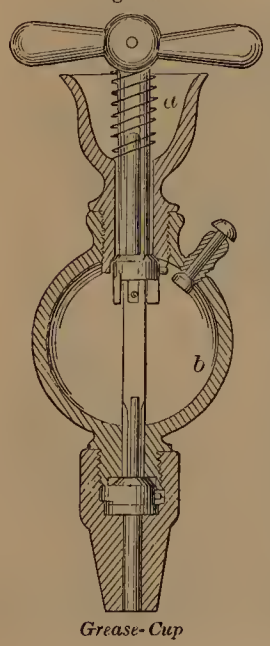
	Length.	Width.	Depth of Water at Sill. Feet.
Canada dock-lock .	500	100	26
Huskisson dock-lock	396	80	24.75
Birkenhead dock-lock	500	85	30.25
16 graving-docks of Liverpool . .	300–700	40–70	18–21
3 Birkenhead graving-docks . .	750	50–70	25.75
10 private graving-docks, Birkenhead	380–440	80–87	19.25–24

Grav'i-ty-bat'ter-y. Invented by Callaud or by C. F. Varley, London; English patent, December 5, 1854, no. 2555. A form of double-fluid battery, in which the fluids range themselves at different hights in a single jar by virtue of their different specific gravities. The copper or − element is in the bottom, and the zinc or + in the upper part of the cell. See CALLAUD BATTERY.

In the ordinary forms of "gravity" or "Callaud" battery, if the sulphate of copper dissolves faster than its solution is used up, the copper solution rises, finally touching the zinc, rendering the battery useless.

R. M. Lockwood, patent April 8, 1873, shows an arrangement for avoiding this. The copper element or a portion thereof is placed at the point where it is desired to maintain the separation of the liquids; so long as the circuit is closed the copper solution will not rise above such element.

Fig. 2309



Grease-Cup

Grease-box. (*Railroad Engine.*) The receptacle over an axle arm, which contains the lubricating material.

Grease-cock. (*Machinery.*) A faucet by which oil is admitted to a journal-box, or other part requiring lubrication. It is used on the cylinder cover for lubricating the piston without permitting the escape of steam or the entrance of air.

Grease-cup. (*Machinery.*) A cup attached to a part requiring lubrication, and from which it is supplied with oil. In the example, the two valves are on the same stem a little more distant apart than are their seats; the revolution of the stem by bringing one or the other of the valves to its seat establishes communication between the supply cup *a* and the globe *b*, or between the latter and the valve-chest. See OIL-CUP.

Grease-pot. An iron pot, the third in the series in which iron plates are tinned. It contains clear melted tallow or lard, and is situated between the *wash-pot* and the *pan*. The series is: *tin-pot*, *wash-pot*, *grease-pot*, *pan*, and *list-pot*. See TIN-PLATE.

Great-or'gan. (*Music.*) One (and the most important) of the three organs which are associated in large combined organs. They are the *great*-organ, the *choir*-organ, and the *swell*; to which may be added the *pedal*-organ or *foot-keys* for acting on the larger pipes. The key-board of the *great*-organ contains the principal keys, and has the middle position, the *swell* having the highest bank and the *choir* the lowest. See ORGAN.

Great Prim'er. (*Printing.*) A type four sizes larger than *Long Primer*.

Long Primer, 89 ems to a foot.
Small Pica, 83 ems to a foot.
Pica, 71 ems to a foot.
English, 64 ems to a foot.
Great Primer, 51 ems to a foot.

Greek-fire. An incendiary composition used in early times by the Tartars, and afterwards by the Greeks.

The invention is ascribed to Collinicus, an architect of Heliopolis, the "city of the sun," afterwards called Baalbec. He is reported to have deserted the service of the Caliph and entered that of the Emperor Constantine Pogonatus, A. D. 673. The Emperor Leo described its use, 911; the Princess Anna Comnena described its properties, 1106; so did Joinville, 1249.

In two sieges, writes Gibbon, the deliverance of Constantinople may be chiefly ascribed to the novelty, the terrors, and the real efficacy of the Greek-fire. It was poured from large boilers on the ramparts, or launched in hollow balls of metal, or darted with arrows and javelins, twisted round with flax and tow which had imbibed the inflammable oil. In naval battles, fire-ships filled with these combustibles were carried by the wind, that fanned their flames against the sides of the enemy's vessels. It was usually blown through long copper tubes, planted in the prow of a galley, and fancifully shaped into the mouths of savage monsters that seemed to vomit a stream of liquid fire. The art of compounding it was preserved at Constantinople as the palladium of the state. Its galleys and artillery might occasionally be lent to the allies of Rome, but the secret of the Greek-fire was concealed with the most jealous scruple for above four hundred years. The Princess Anna Comnena, in mentioning resin, sulphur, and oil as its components, only intended, it is probable, to baffle curiosity by telling just so much as everybody knew already.

In 1098, the fleet of Alexis Comnenus used Greek-fire against the Pisans. His ships had "siphos" fore and aft, in form of syringes, which squirted the inflamed matters.

It is believed that the ancient Byzantium was marked by the present walls of the Seraglio. Con-

stantine enlarged it A. D. 328, gave it its name, and made it the rival of Rome. It was taken from the Greeks, in 1204, by the Venetians under Dandolo; retaken by the Greeks, in 1261, under the Emperor Michael Palæologus; captured by the Turks in 1453.

An old recipe for Greek-fire is thus given: —

"Aspaltum, nepta, dragantum, pix quoque Græca,
Sulphur, vernicis, de perolio quoque vitro,
Mercurii, sal gemmæ Græci dicitur ignis."

Another reads as follows: "Take of pulverized resin, sulphur, and pitch equal parts; one fourth of oppopanax and of pigeons' dung well dried, dissolved in turpentine water or oil of sulphur; these put into a strong, close, glass vessel and heat for 15 days in an oven; after which distill the whole in the manner of spirits of wine and keep for use."

The contact of water would increase the violence of this villainous compound.

The savans of the Middle Ages were well acquainted with a number of explosive mixtures, some of which were especially effective by the liberation of poisonous gases which asphyxiated the enemy. In effect like our modern stink-balls, but not thrown, like the latter, from a gun or mortar, but projected by squirts or in bottles, after the manner of a hand-grenade. Prester John, who seems to have combined regal and sacerdotal powers somewhere in Tartary about the eleventh century (some say the thirteenth), is cited as particularly skilful in blowing up his enemies. He stuffed — so says the legend — copper figures with explosive and combustible materials which were emitted at the mouths and nostrils of the effigies, making great havoc.

The Danish historian, Saxo Grammaticus, A. D. 1200, gives an account of a similar contrivance, used by a Gothic king. The devices of Archimedes, who defended Syracuse from the Romans, 212 B. C., were mechanical or optical, and do not seem to have involved chemical compounds.

Green-house. 1. (*Pottery.*) A house moderately warmed, where some kinds of *green-ware* are placed to become partially dried before taking to the *hot-house*, where the drying is completed by strong heat.

The ware is then arranged in seggars and *fired* in the kiln.

2. (*Horticulture.*) A plant-house, with glass roof and sides, with facilities for maintaining an artificial temperature and the necessary ventilation.

Gre'go-ri-an Tel'e-scope. The first and most ordinary form of reflecting telescope, invented by Professor James Gregory of Scotland, and described by him 1663.

Its object mirror or speculum is perforated in its axis, and reflects the image to a smaller concave speculum placed in the axis of the tube at a distance from the larger speculum. The image is viewed through an eye-piece in the aperture of the object-speculum. See TELESCOPE.

Gre-nade'. (Italian *grenado.*) A small shell weighing about two pounds, and thrown by hand. It is said to have been first used at the siege of Wacklindonck, near Gueldres. The right company of each battalion was formerly composed of the taller men armed with hand-grenades. Hence the term *grenadiers.* Various forms of grenades have been invented, some containing combustibles, missiles of various sorts, Greek-fire, or other incendiary compounds. 6-pounders, and even larger shells, have been used as rampart grenades, being rolled over parapets against assailants.

The Orsini grenades, with which an attempt was made to assassinate Louis Napoleon, were spherical shells containing powder and missiles, and having a large number of cones or nipples, each capped with a gun-cap. They were made in London.

Gren'a-dine. (*Fabric.*) A gauzy dress goods, silk or wool, plain, colored, or embroidered.

Grid. 1. A gridiron.

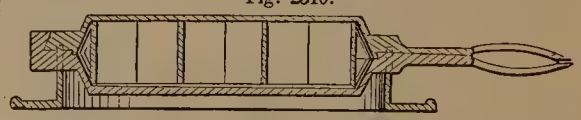
2. A grating of parallel bars, for a furnace, stove, window, vault-cover, or sewer opening.

3. A grating. Used as a concave, partially enclosing the toothed cylinder of a thrashing-machine, or the scutching beater of a cotton-batting machine. *Grids* have other uses; their essential feature of construction consists in having alternating bars and spaces, the latter afford space for the escape of matter or the passage of air.

Grid'dle. 1. A miner's sieve for separating the ore from the *halvans.*

2. A flat plate of iron long known as the *gurdel*, and used from remote antiquity for cooking flat cakes of dough upon a fire on the hearth. We find mention of the use of this implement in all histories, in the Bible, and among the classic writers, and in the Egyptian paintings. A bag of oatmeal and a *gurdel* was the ordinary furnishing of a Scottish soldier in the time of Edward III. The equipment of the Goths was substantially the same.

Fig. 2310.

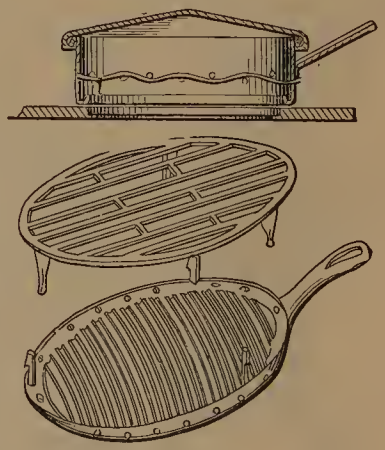


Reversible Griddle.

In the example, two dish-shaped cast-iron plates have projecting ears, and when placed together form a hollow dish to contain nests for cakes, etc. The griddle is supported by its projecting ears, which form journals whereby it is turned over upon a rim placed upon the pot-hole of a stove or range.

Grid'i-ron. 1. (*Hydraulic Engineering.*) A grated frame on which ships are hauled out of the water for examination, cleaning, and repairs. Or a framing of cross-timbers which receives a ship with the falling tide.

Fig. 2311.



Gridirons.

2. (*Domestic.*) A grated iron utensil on which fish, flesh, and fowl are exposed for broiling. The illustrations show a gridiron with a wire grating and a sheet-metal rim and cover; one with legs, and another griddle-shaped. See also BROILER.

Grid'i-ron-pend'u-lum. A compensation pendulum invented by Harrison. The bob is supported by parallel bars of two metals which are unequally expanded by heat. These are so disposed that, while one tends to lengthen it, the other tends to shorten it. The ratio of lengths is determined by the relative expansibility. See PENDULUM.

Grid'i-ron-valve. (*Steam-engine.*) A valve whose opening is divided into a number of narrow parts by which the travel may be abridged.

Griff. (*Weaving.*) A series of horizontal parallel-edged bars, also known as *knives* or *blades*, arranged in a reciprocating frame to raise and lower the vertical hooked rods connected to the *shedding* mechanism, when the hooked ends of said rods are brought by a pattern device within the path of said knives.

Gril'lage. (*Hydraulic Engineering.*) A structure of sleepers and cross-beams forming a foundation in marshy soil for a pier or wharf.

Grind'ing and Pol'ish-ing. See under the following heads: —

Ayr-stone.
Bob.
Border.
Bowldering-stone.
Brayer.
Bristol-brick.
Brush-wheel.
Buffing-machine.
Buff-stick.
Burnisher.
Burnishing-machine.
Cadrans.
Cane-polishing machine.
Card-grinding machine.
Charcoal.
Clearing-stone.
Coffee-polishing machine.
Colcothar.
Corundum.
Crocus.
Cylinder grinding, etc.
Dial.
Diamond-cutting, etc.
Dop.
Drill-grinding machine.
Dry-grinding.
Dutch rush.
Emery.
Emery-paper.
Emery vulcanite-wheel.
Emery-wheel.
File-grinding machine.
Fish-skin.
French-polish.
Gem-cutting, etc.
Glass-cutting.
Glass-paper.
Glass-polishing.
Glazer.
Glazing-wheel.
Gouge-slip.
Grinding and polishing materials.
Grinding-machine.
Grinding-clamp.
Grinding-mill.
Grinding-slip.
Grinding-wheel.
Grindstone.
Grindstone. Artificial
Grindstone-dresser.
Holystone.
Hone.
Lap.
Lapidary's mill.
Lead-mill.
Lens. Grinding, etc.
Liner.
Lustering.
Marble-polishing.
Martin.
Mill (varieties, see MILL).
Mortar.
Muller.
Oil-stone.
Palette.
Paper-polishing machine.
Plate-powder.
Polishing materials.
Polishing-mill.
Polishing-needles.
Polishing-powder.
Polishing-slate.
Polishing-snake.
Polishing-tin.
Porphyrization.
Porte-polish.
Pumice-stone.
Putty-powder.
Rabat.
Rabot.
Ragging.
Razor-strop.
Reaper-bar grinder.
Reaper-knife sharpener.
Red-stuff.
Rifle.
Rouge.
Rottenstone.
Roughing-mill.
Rubber.
Rub-stone.
Rumble.
Sand-blast.
Sand-jet.
Sand-paper.
Sand-papering machine.
Saw-grinding.
Saw-sharpening machine.
Scorching.
Scratch-brush.
Scythe-stone.
Shaking-machine.
Shave-grass.
Sheet-metal polisher.
Skate-grinder.
Skive.
Slate-making machine.
Slicer.
Slitting-mill.
Smoothing-mill.
Spade.
Spring-polisher.
Steel.
Stone-grinding machine.
Stone-polishing machine.
Straggling.
Strickle.
Tanite.
Tape-carrier.
Tool-holder for grinding.
Tripoli.
Tumbler.
Varnish.
Whetstone.
Whiting.
Whetter.
Wood-polishing machine.

Grind'ing and Pol'ish-ing Ma-te'ri-als. Abrasive substances used in the solid form: —

Grindstone.
Hone.
Oil-stone.
Charcoal.
Emery-cake.
Fish-skin.

Abrasive substances used in powder; materials stated in about the order of their hardness: —

Diamond.
Sapphire.
Ruby.
Corundum.
Emery.
Sand.
Flint.
Glass.
Tripoli.
Turkey-stone dust.
Rottenstone.
Slate.
Pumice.
Chalk.
Oxide of iron, colcothar.
Crocus or rouge.
Oxide of tin or putty-powder.

The abrasive powders are applied by thin circular disks, which cause them to act as *saws*.

On the periphery of wheels which act as *grindstones*, *glazers*, or *buffs*, according to the quality of the material and the terms of the trades.

On plane surface of disks which form *laps*.

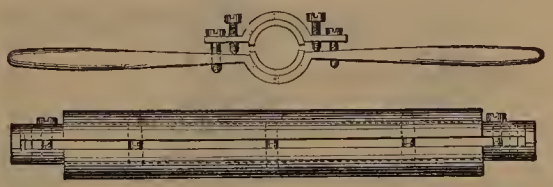
On the ends of rods which act as *drills*.

On slips of wood which act as *files*.

Spread upon cloth, paper, or leather, forming a grinding or polishing paper or pad, as the case may be. See EMERY-PAPER; SAND-PAPER; etc.

Grind'ing-clamp. A grinding-clamp for cylindrical work has two semi-cylindrical leaden blocks enclosed between the two halves of the clamp, which

Fig. 2312.



Grinding-Clamp and Rod.

are adjusted by binding-screws. The halves of the clamp are adjusted to the desired distance, slips of wood being placed in the jaws while the melted lead is run in to form the cheeks.

For internal work the grinder consists of two semi-cylindrical rods of iron, fitted to each other by dowel-pins and set screws, so as to be expanded to the required distance. The leaden cheeks are cast upon the rods, which are placed in a mold for that purpose.

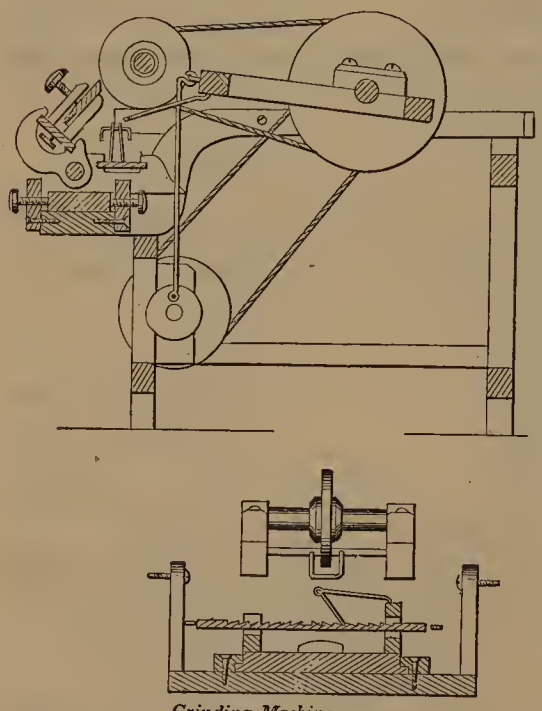
Grind'ing-frame. An English term for a cotton-spinning machine.

Grind'ing-ma-chine'. Fig. 2314 shows a machine in which the article to be ground is moved past the face of the grindstone, which is stocked in a swinging frame for the purpose of giving to the bezel of the tool or implement a concave form, having a greater radius than that of the stone.

Fig. 2314 shows Whitelaw's machine for grinding pulleys. *a* is the grindstone, which is caused to revolve at about 180 turns a minute in one direction, while the pulley *b* rotates at about 130 revolutions per minute in the other.

The pulley is caused to traverse back and forth across the face of the stone by bevel-gearing connected with the crank-shaft *c*, and is kept up to the stone by similar gearing from the shaft *e*, operating the screws *d d d*, through the hand-wheel *f*.

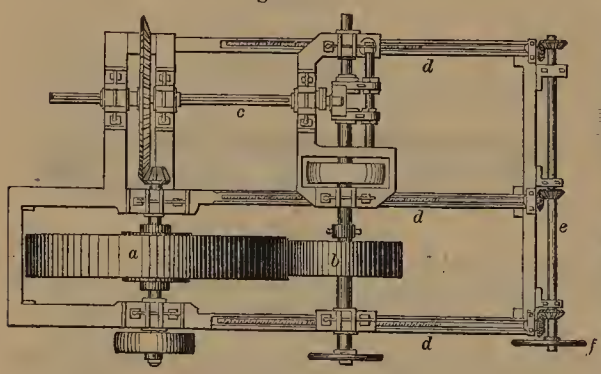
Fig. 2313.



Grinding-Machine.

Grind'ing-mill. 1. The original grinding-mill was a mortar; a hollowed stone in whose depression the parched grain was pounded by a bowlder. Such

Fig. 2314.



Grinding-Machine.

stones are found amongst most nations possessing food requiring such treatment. The North American Indians, who had maize, pounded it in this manner to make a coarse meal or hominy; large stones in their villages formed permanent mortars. Their pestles were sometimes fortuitous bowlders of convenient shape, sometimes they were fashioned into a shape like a painter's muller, or even approximating the form of dumb-bells. Collections of curiosities abound with specimens of this rudimentary grinding-mill. The Smithsonian Institution has many such from North America and the South Seas.

The *mortarium*, or *mola trusatilis*, was a modification of this form, and Pliny states the bread made of the broken grain to be superior, in the estimation of some, to that more closely ground in the mills of more perfect construction, and leaves us to infer that throughout the greater part of Italy the grain for bread is pounded in a mortar by an iron-shod pestle. The Romans had great variety of bread, the best and most fashionable the *alica;* also *ostrearius* (oyster-bread), *artolagonus* (cake-bread), and many others. (See Bread.) A passage in Pliny suggests that in course of time the mortar was ridged and the pestle notched, forming a machine which had a grating action upon the grain. See Mortar.

When the upper stone or *runner* was enlarged and furnished with a handle, by which it was rotated upon the nether or bed-stone, the device may be said to have crossed the line between the *mortar* and the *mill*. The grain was fed in at an eye in the axis of the runner, and the meal escaped at the space between the stones at the outer margin of their effective faces, as shown at Fig. 2315. Such a mill was the *quern*, common in Italy and Britain in Roman times and since.

The ancient Egyptian mills, says Wilkinson, were of simple and rude construction. They consisted of two circular, horizontal stones, nearly flat; the lower one fixed, while the upper one, called the *rekkab*, or rider, in Arabic and Hebrew, turned on a pivot or shaft rising from the center of the lower one. It was turned by two women, seated, each holding the perpendicular handle, and operating by a concerted push and pull motion. The modern Egyptian hand-mill is substantially similar. Their larger mills were turned by oxen or asses, like those of the Romans. The millstones were of hard grit or granite, and are occasionally met with in the ruins.

The grinding of grain for a family was performed by women or slaves, and, the grist being usually sufficient for a single meal only, the work was a daily

Fig. 2315.

Oriental Mill.

occurring one. Samson ground in the prison-house. Job spoke of his wife grinding for a stranger. The Master spoke of the days of tribulation surprising two women grinding at the mill. Moses forbade the taking of the millstone to pledge, as it was a man's life, — a daily necessity, a grist for a meal being ground at a time. The last of the Egyptian plagues was the death of the first-born, from that "of Pharoah that sitteth upon his throne, even unto the first-born of the maid-servant that is behind the mill." The citation seems to include the extremes of the social scale.

When the labor of cattle was substituted for that of mankind, the upper millstone was called *meta* and the lower *catillus*, such mills being known as

molæ jumentariæ. The sweep to which the cattle were yoked was fastened to the runner which rotated upon the bed-stone. Since a time that the memory of man runneth not to the contrary, the Phœnicians have had mills for bruising olives, constructed on the plan of the Chilian mill, one stone rolling on its edge in a circular track around a post planted vertically in the center of the track. (See OIL-MILL.) Such was probably a common form of the Syrian cattle-driven grain-mill.

The cattle-driven grain-mills in Rome, about the time of Constantine, numbered three hundred.

Strabo informs us that mills were driven by water in the period of Mithridates of Pontus, the contemporary of Cæsar and Cicero. Such mills were driven by the current of the Tiber a little before the time of Augustus. It is not certain that these were grain-mills.

Windmills were introduced from Greece by one Paulo, and were used for grinding grain, if we may credit Pomponius Sabinus.

Antipater, time of Cicero, refers distinctly to the use of water-mills in an epigram:—

"Cease now your work, ye maids, ye who labored in the mill; sleep now, and let the birds sing to the ruddy morning, for Ceres has commanded the water-nymphs to perform your task; these, obedient to her call, throw themselves on the wheel, force round the axle-tree, and by these means the heavy mill."

Palladius advises the erection of water-mills on estates where streams afford the opportunity of saving manual labor in grinding grain.

Public mills were established in Rome A. D. 398, and were driven by the surplus of water brought to Rome by her splendid aqueducts. They were principally at the foot of Mount Janiculum.

In the sixth century (A. D. 536), when Vitiges, king of the Goths, harassed Rome, and stopped the water of the fourteen aqueducts which entered the city, the mills were stopped thereby, and great distress was the consequence. The grand old soldier Belisarius moored boats in the current, and provided them with paddle-wheels, by which the mills were driven and the people supplied with meal. The Goths tried to destroy them by throwing logs into the stream, but the Romans intercepted these by booms.

Water-mills soon became common in Gaul and Germany, and we read of some on a tributary of the Moselle A. D. 379, and a mention of them by Fortunatus in the next century.

It is needless to particularize farther, as the notices of water-mills in France, Bulgaria, Italy, and elsewhere, are numerous in the writers from the fifth century down.

The moving stone, known as the *runner*, is usually the upper stone, as shown at Fig. *G* in the plate on the page opposite. Variations from this practice are shown at *K*, where the *runners* are beneath, and at *F*, where both stones are driven, but in contrary directions.

The following terms apply to grinding-mills and to parts many of which are represented in figures *G H* of the plate. *L* is an enlarged view of the parts around the spindle and eye.

Bed-stone (*a*); a stationary millstone, usually the lower one.

Runner (*b*); a revolving millstone, usually the upper one.

Run of stones; a pair of millstones in working order.

Spindle (*d*); a shaft which supports and drives the runner.

Step or *ink* (*e*); the socket which holds the *toe* of a vertical shaft or spindle.

Bridge-tree (*f*); the beam which supports the *ink*.

Bush (*g*); wooden chocks called *followers* surrounding the spindle within the eye of the bed-stone. The upper bearing of a millstone-spindle.

Keys (*h*); wedges by means of which the bush is fastened in the bed-stone.

Driver (*i*): a cross-bar by which the motion of the spindle is conveyed to the runner.

Coffins; sockets in the eye of the runner for the ends of the driver.

Balance-rynd (*j*); an iron bar stretching across the eye of the runner, and by which it is poised on the spindle.

Cock-eye (*k*); a cavity on the under side of the balance-rynd to receive the point of the spindle.

Cock-head; the upper point of a millstone-spindle.

Horns; the points of the driver.

Eye (*n*); the central aperture of a millstone.

Hoop (*o*); the enclosing case of a run of stones.

Hopper (*p*); a conveying trough or funnel for feeding a mill.

Shoe (*q*); a conducting spout or trough from the hopper to the eye of the stone.

Spout (*r*); the issuing nozzle for the ground meal. A projecting ventage.

Damsel (*s*); a projection on a millstone-spindle for shaking the shoe.

Dress; a system of land and furrows. A mode of preparing the grinding-surface.

Face; the grinding-surface of a millstone.

Rynd; the bar by which the runner is poised on the cock-head.

Skirt; the outer margin or edge of a millstone.

Furrows; grooves in the face of a millstone to expedite the grinding action.

Land (*x*); level surface between millstone furrows.

Leader (*t*); a furrow extending from the eye to the skirt of a millstone.

Second furrow (*u*); the branch-furrow nearest the eye of a millstone.

Skirt-furrow (*v*); the branch-furrow nearest the skirt of a millstone.

Gouge-furrow; one concave at bottom.

Track-edge; the abrupt edge of a millstone furrow.

Feather-edge (*w*); the shallow edge of a millstone furrow.

Quarter (*y*); a section of millstone dress consisting of a leader and its branches.

Bosom (*z*); a sunk area in the face of a millstone around the eye.

Tram-staff; an instrument to test the squareness of the spindle with the face of the bed-stone.

Red-staff; a straight-edge employed to detect irregularities in the face of a millstone.

Proof-staff; a metallic straight-edge by which the red-staff is corrected.

Wing (1); a strip (commonly of leather) attached to the skirt of the runner to sweep the ground meal into the spout.

Lighter-screw (2); a screw for adjusting the relative distance of the grinding-surfaces.

Husk (3); the supporting frame of a run of millstones.

Grit; a kind of sandstone.

Grits; hulled and coarsely ground grain.

Food; the substance being ground.

Cutlins; half-ground fragments of grain.

Dressing; preparing the face of a millstone for grinding.

Face-cracking; roughening the land-face of a stone by means of numerous blows with a pick-hammer.

Tramming; adjusting the spindle so as to be exactly at right angles with the bed-stone face.

Raking; an action in which, the runner being out of balance, one edge rakes or presses unduly.

Chuckle; the runner is said to chuckle when it rocks upon its center while rotating.

Facing; preparing the working-surface or *face* of a millstone.

Wreathe; the food is said to wreathe when its particles hug the eye so closely as to retard or prevent their descent.

Sling; to swing from side to side (applied to a millstone).

In tram; the spindle being perpendicular with the face of the bed-stone.

Out of tram; the spindle being oblique with the face of the bed-stone.

Gummed; having an indurated coating of vegetable matter.

Killed; meal over-heated in the act of grinding.

Round; not unduly pulverized; meal rather granulated than powdered.

Bush loose; loose in its upper bearings (applied to the spindle).

Draft; the degree of deflection of millstone furrows from a radial direction; thus, in a *seven-inch draft*, the track-edges are tangential to a seven-inch circle.

Fourteen quarter dress; a system of fourteen sets of furrows.

Grit; degree of hardness or texture, — as hard grit, soft grit, coarse grit.

The term *hopper*, although now usually applied to a stationary conductor or funnel, was formerly applied to a shaking one, and hence the name.

The *killing* of the meal usually takes place between grinding surfaces, which, having been worn smooth and somewhat glazed, are set too closely together, and the flour, sliding between instead of rolling over the surfaces, becomes parched, so as to impair its vitality and capacity for panary fermentation. A perfect dress will *slide* the bran and *roll* the flour.

A of the plate is a form of portable mill, adapted to be worked by manual labor, or, by substitution of a band wheel for the crank, by horse-power. The shaft has a bevel-wheel gearing into a pinion on the spindle of the runner.

B is an English form of hand-mill made for the colonies and foreign market. It has a fly-wheel, bevel-wheel, and pinion, which drive the upper stone. Both stones are of buhr. The grain is fed from the hopper in the usual manner, and conducted by the shoe to the eye of the runner, a damsel on the millstone-spindle shaking the shoe.

In some mills and in many forms of corn-crackers metallic plates have been substituted for stones. Among the first of these was the French military mill, the invention of Francis Devreux, to whom a patent was granted for it in 1824. The principle is that of metallic groove plates turning in a vertical plane; the grooves cut radiating from the center of the plate. One of the plates is fixed to the end of the frame of the mill; the other revolves upon an axis fixed in the center of the fixed plate at one end, and in the side of the frame in the other. The grain is fed through an aperture in the fixed plate. See millstone-plate.

E is an emigrant mill, attached to the tongue of a wagon, and designed to be worked by two cranks.

The Shakers of New York reduce their roots to powder by means of a crushing-mill *C*, succeeded by a powdering-mill *D*. The first is on the principle of the Chilian mill, and reduces the dried roots to the size of samp or fine hominy. The stones are of Esopus granite, 4 feet diameter, 1 foot thick, and weight 2,000 pounds each. They turn on their axle, which is at right angles to the vertical axis by whose rotation they are caused to revolve around a common center, and also rotate on their own axes. The principle of the Chilian mill is well understood, and its effect is very powerful. As the outer periphery or face of the stone describes a larger circle than the inner, the face of the stone has a constant rubbing action on the bed-plate, and the material subjected to the action of the stones is much more forcibly grated than it would be by the mere crushing weight of a traversing stone.

The roots, cracked and reduced to a certain fineness in the crushing-mill, are next placed in the powdering-mill *D*, which has a rounded bed-stone of granite and two runners in the shape of truncated cones, which have a rotation on their own axes, and also a revolution around the vertical axle by which the power is transmitted. This mill is very effective. In this form of grinding-mill is illustrated the crushing action just referred to. The outer portion of the face of the upper stones — or that portion of each which for the time being is nearest to the rim of the bed-stone — is subjected to the greatest amount of attrition, being farthest from the common, vertical axis of revolution; it thus causes the other portion of the face, or that nearest the center of the bed-stone, to advance in the general direction of motion, the outer portion being detained by the greater friction, and the result being a rotation resulting from the revolution. Rotary harrows are constructed on the same principle, a rotation being imparted to the individual harrows by power exerted in the direct line of draft.

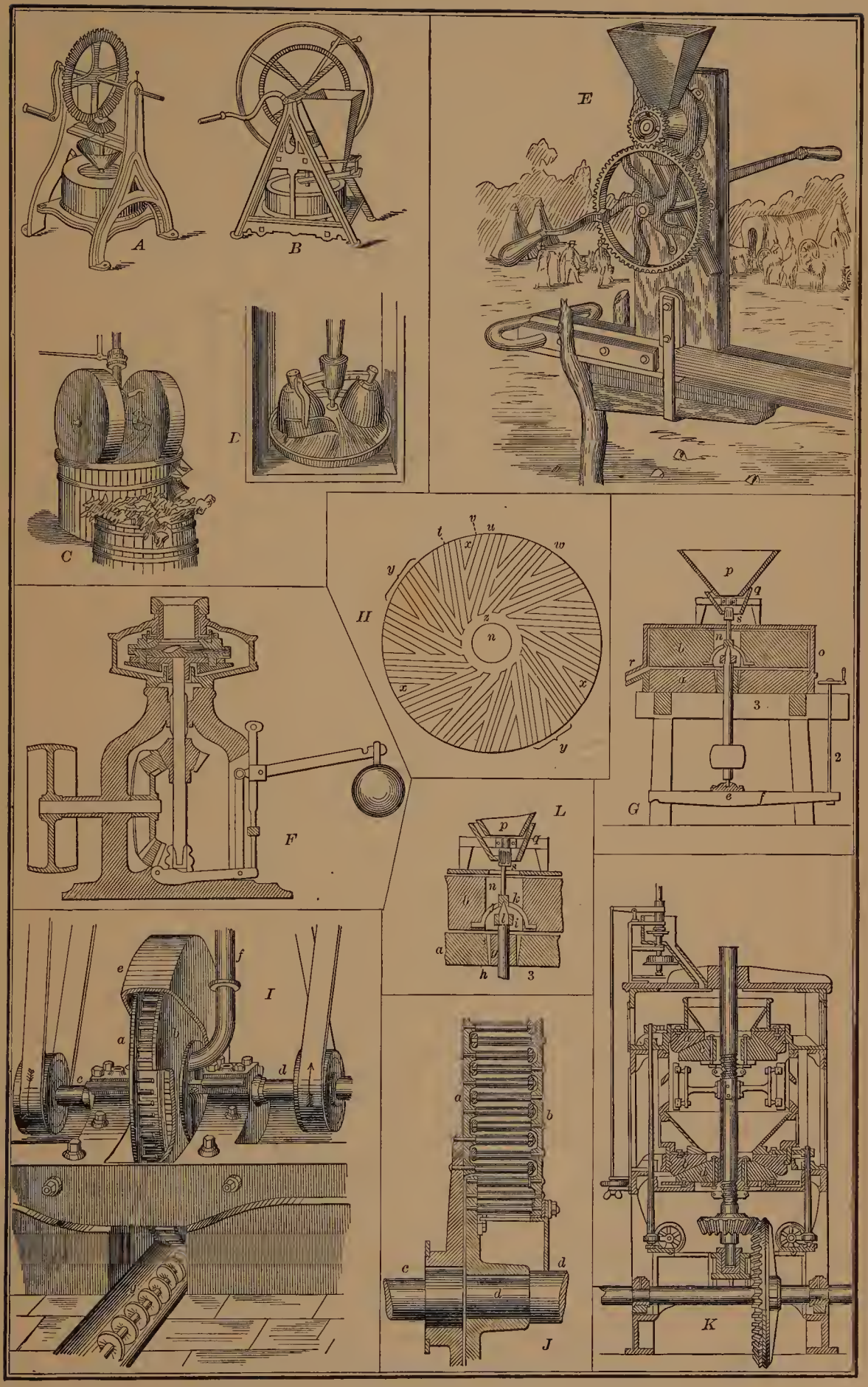
In one form of the English farm-mill *F* the upper and lower plates rotate in the same direction and at nearly equal velocities, but not on the same center. Their eccentric setting gives their grooved surfaces a shearing cut upon each other.

Carr's disintegrating flour-mill (English) is shown by a general view at *I* and by a partial sectional view at *J*.

a and *b* are circular metallic disks, which rotate in contrary directions upon the shafts *c* and *d*, which are situated in the same line. On the inner surfaces of these disks are concentric rings of projections, called *beaters*, the rings on one disk intervening alternately with those on the opposite disk, and moving in a contrary direction. Several concentric rings of beaters may be thus made to operate conjointly.

The revolving beaters are inclosed in a casing *c*. The grain is delivered down the fixed shoot *f* through the orifice in the outer casing, into the innermost cage, from which it is instantly projected by centrifugal action through the machine and delivered, in a shower radiating from every portion of the circumference, into the outer casing, in the form of a meal similar to that thrown out by the ordinary millstones; to this state the grain is reduced by being dashed to the right and left alternately by the bars of each of the successive cages revolving in opposite directions at a very high rate of speed. As it falls to the bottom of the casing, the meal is continually removed by the screw *g*; it is then passed through the usual bolting-machines to separate the bran, and subsequently through silk dressing-machines to separate the fine flour.

The machine is driven at a speed of about 400 revolutions per minute; and the outermost ring being 6 feet 10 inches diameter, the last beaters have a velocity of 140 feet per second, or about 100 miles per hour.



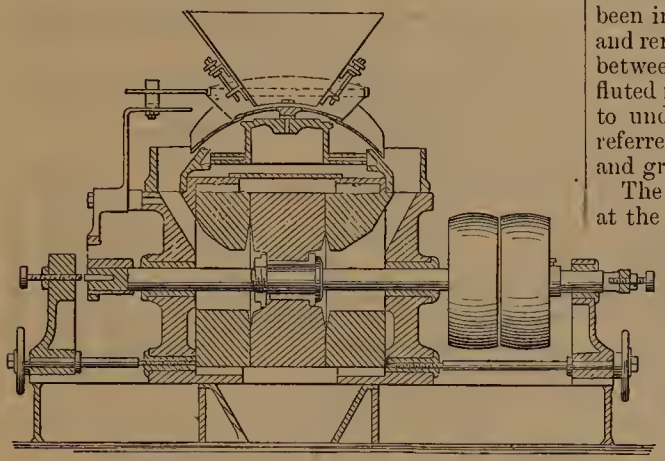
GRINDING-MILLS.

PLATE XXII.

See page 1020.

K represents Westrup's conical buhr-stone flour-mill. In, this the upper stone is fixed while the lower revolves, and weighs but about 1½ cwt. instead of 14 cwt., as the ordinary stones do. *a* is the upper, *b* the lower fixed stone; *c* the upper and *d* the lower runner, both fixed on the same spindle.

Fig. 2316.

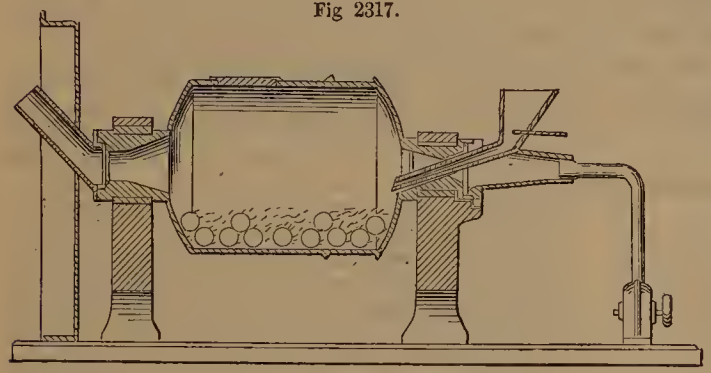


Horizontal-Shaft Grinding-Mill.

This arrangement diminishes the power required, and is said to deliver a much larger quantity of flour in the same time.

Fig. 2316 is a form of mill in which the runner rotates with a horizontal shaft passing through boxes in the adjustable standards, by whose movement the other stones are adjusted. The grain passes from the hopper through two spouts, and passes through ways in the standards and the side stones.

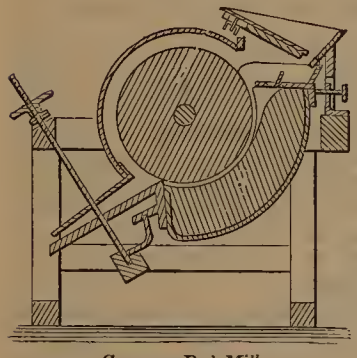
Fig 2317.



Rolling-Balls Grinding-Mill.

In Fig. 2317 the material is fed into the cylinder through one of the tubular journals, and is subjected to the action of metallic balls running loosely in the rotating cylinder. A blast enters through the inwardly flaring aperture of the journal at the feed end and carries the powdered particles through the other journal to the receiving chamber.

Fig. 2318.



Concave-Bed Mill.

In Fig. 2318 the bed-stone is a concave, which may yield to any hard substance and preserve it from injury.

Many of the new processes for putting wheat into a convenient shape for cooking are but revivals of old modes. We have spoken in this article, and under BREAD, of the Roman preference for decorticated grain, rasped in a mortar and then simply broken. The Hungarian plan, which may have been in use for centuries, is to decorticate the grain and remove the bran, and then rasp the hulled kernels between a complicated series of differently speeded fluted rolls. Other devices for this purpose are referred to under DECORTICATOR; and allied machines are referred to under HULLER. Pearl barley, hominy, and grits are hulled grains.

The ventilating of millstones, by a blast of air in at the eye and out at the skirt, is old as Gendebein and Houyet's patent, January 5, 1847. They proposed to use plenum or vacuum.

Oliver Evans's *hopper-boy* patent, a means of feeding grain to the millstone, was pronounced by Thomas Jefferson so important that the inventor ought not to be allowed a patent on it, it being an absolute necessity to a miller when once discovered.

The regrinding of roughly ground or coarse meal was practiced by the Romans, and has been revived in latter times by the Germans and French; by the latter under the name *mouture économique*. The grain is coarsely ground, bolted; the coarse portions and bran reground again and again. The various grades and kinds of flour or meal thus obtained were called by Pliny *similago, simila, flos, pollen, cibarium*.

Two other plans may be noticed; one which produces what is called *entire wheat flour*, the bran being ground to an impalpable powder and mixed with the flour. Also a French plan, in which grinding is dispensed with; the wheat being decorticated, macerated, and crushed by rollers into a dough fit for baking.

The first steam flouring-mill in England, perhaps in the world, was the "Albion," erected at the Southwark end of Blackfriars' Bridge, London, in 1783.

The best-appointed *grinding-mill* in England is said to be the City Flour-Mill of London. Its capacity and arrangement are thus described by Mr. Tomlinson: —

"The mill, which is fire-proof, is 260 feet in length and 60 in width. There are thirty-two pairs of stones all furnished with the blowing-apparatus, the runner of each pair being worked by a strap. A long horizontal trunk placed above the millstones is supplied with condensed air by means of a powerful fan. From this trunk proceeds a smaller trunk obliquely into the casing of each pair of millstones, and when the blast has served its purpose it escapes up another oblique trunk, into a second long horizontal shaft, in which the air is rarefied by means of a fan. This fan conveys the air into a chamber lined with woolen cloth which arrests the flour carried off by the blast.

"The wheat is hoisted to the top floor, where, after undergoing certain cleansing operations, it is let down to the stones. The meal is conveyed along horizontal trunks, by means of archimedean screws working in them, to a series of bucket-elevators attached to an endless band working in a vertical plane over and under rollers at the top and bottom. These elevators distribute the meal among sixteen

silk dressing-machines, each of which is 36 feet long, 3½ feet in diameter, and inclosed within a wooden casing. The silk-machine consists of an octagonal wooden framework attached by radial bars to a central axis. The frame is covered with a fine silk cloth, hard in texture and tightly stretched. The axis is inclined ¾ inch to each foot of its length ; the two ends are open, and the meal, being poured in at the upper end, is sifted through the bolting-cloth which covers the eight sides, as the frame revolves.

"As a means of jarring the frame to prevent the clogging of the meshes of the bolting-cloth, the radial rods of the frame have wooden balls threaded loosely upon them, so that as the frame revolves they fall from the axis upon the circumferential bars, and then back again upon the axis as the position of the radial bars changes. The fine flour which passes through the cloth is conducted to a bin ; the pollard and bran are conducted to a dressing-machine.

"The average quantity of wheat ground per week is 20,000 bushels. Wheat can be ground and dressed in fifteen minutes, during which time it passes three times from the top to the bottom of the mill by means of screws and elevators. But few hands are employed, the work of the mill being mostly performed by steam-driven machinery. The steam-engine in this establishment is on the marine principle, and was formerly one of the stationary engines of the Blackwall Railway, when the carriages on that line were moved by means of a rope.

"The nominal power of the engine is 220-horse-power. There are seven boilers for generating steam, and they are made to consume the smoke by causing one fire as soon as it is supplied with coals to discharge its smoke into the adjoining furnace."

2. A lapidary's wheel of lead, the disk surface of which is touched with emery and water. It follows the *slitting* or *roughing* mill, and like them is mounted to rotate on a vertical axis. See LAPIDARY'S MILL.

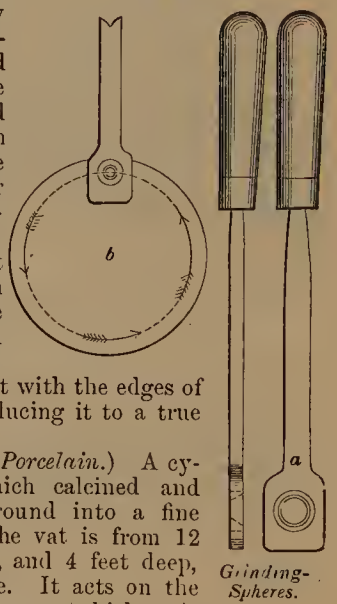
See under the following heads for mills and parts of mills : —

Bag-clasp.
Bag-holder.
Balance-rynd.
Barley-mill.
Bed-stone.
Bolt.
Bolt-feeder.
Bolting-mill.
Bosom.
Bran-duster.
Bridge-tree.
Bruiser.
Bruising-mill.
Brush-wheel.
Buckwheat-huller.
Buhr.
Clack.
Cider-mill.
Clay-mill.
Cock-eye.
Cock-head.
Corn-mill.
Cotton-seed mill.
Damsel.
Debranning-machine.
Decorticator.
Dress.
Feed-regulator.
Flax-seed mill.
Flour-bolt.
Flour-cooler.
Flour-dressing machine.
Flour-packer.
Foot-stalk.
Furrow.
Furrowing-hammer.
Grain-conveyor.
Grain-dryer.
Grain-elevator.
Grain-gage.
Grain-huller.
Hand-mill.
Hominy-machine.
Hoop.
Hopper.
Hopper-boy.
Huller.
Hulling-machine.
Husk.
Kern.
Kibbling-mill.
Lighter-screw.
Mill (varieties, see MILL).
Mill-hopper.
Mill-pick.
Millstone.
Millstone-balance.
Millstone-bridge.
Millstone-dress.
Millstone-dresser.
Millstone-feed.
Millstone-furrower.
Millstone-hammer.
Millstone-pick.
Millstone-regulator.
Millstone-ventilator.
Pane.
Proof-staff.
Red-staff.
Runner.
Rynd.
Shoe.
Sifting-machine.
Smut-machine.
Tram-staff.
Ventilating-millstones.

Grind'ing-slip. A thin slab of oil-stone or hone to reach edges of tools which cannot be conveniently applied to the usual stone.

Grind'ing-spheres. Fig. 2319 illustrates Guy's device for grinding balls to a true surface. The ball, previously turned as nearly spherical as may be, is placed in the conical aperture of the holder *a*, and two rings *b* set from each other a distance equal to the diameter of the ball and pressing tightly against it, are made to rotate at right angles to each other, carrying the ball with them and bringing its protuberant portions in contact with the edges of the aperture, thus reducing it to a true spherical surface.

Fig. 2319.



Grinding-Spheres.

Grind'ing-vat. (*Porcelain.*) A cylindrical tank in which calcined and stamped flints are ground into a fine paste with water. The vat is from 12 to 14 feet in diameter, and 4 feet deep, paved with chert-stone. It acts on the principle of the ARRASTRA (which see), large blocks of chert being attached by chains to revolving arms and dragged upon the pavement of the vat. Chert-stone is used because of its chemical affinity to the liquid, in order that no deleterious ingredients may be introduced by the mutual attrition of the *muller* and pavement in this operation, which is equivalent to porphyrization.

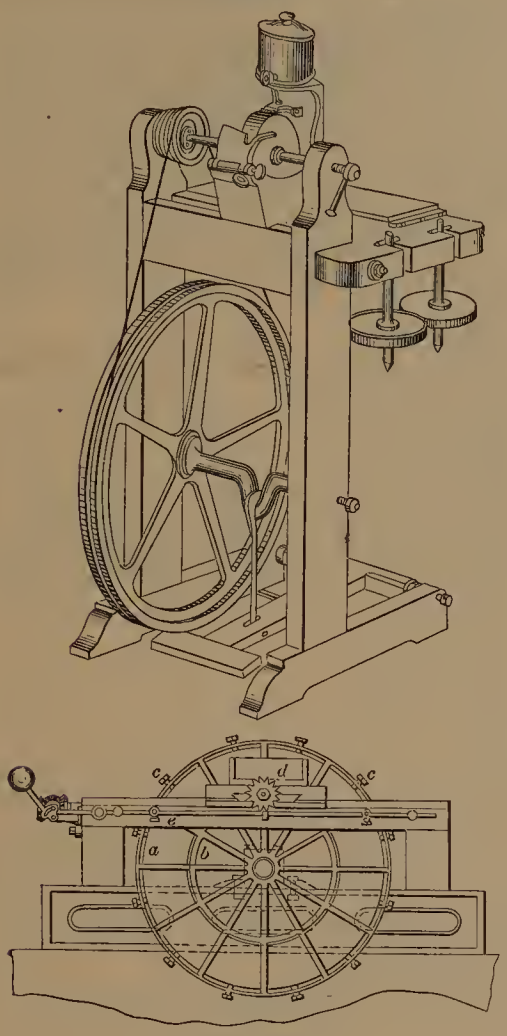
Grind'ing-wheel. Fig. 2320 is a small grinding and polishing machine, adapted for receiving various interchangeable spindles carrying grindstones, emery-wheels, or a circular brush. It is operated by a treadle, has a stand for a water-can, and slots at the sides in which the spare wheels with their spindles may be placed.

The lower machine in the same figure is adapted for grinding large flat surfaces. It consists of an inner and an outer circle *a b*, between the radial divisions of which segmental pieces of grindstone are inserted and fixed by set screws *c c*. The work is placed on the carrier *d*, which traverses on the table *e*.

a b c (Fig. 2321) represent guides for giving a uniform bevel to the cutting-edges of tools. In *a* this is effected by blocks of wood having the proper slope, to which the tool is fastened and the block clamped to the table. *b* is provided with a quadrant which allows of a vertical adjustment. The grinding-wheels *d e* are horizontal. *c* is adapted for affixing to a block, which is applied alongside of a vertical wheel. The tool is clamped to a holder, which has horizontal and vertical graduated arcs, admitting of adjustment to any required angle, so as to form a double bevel.

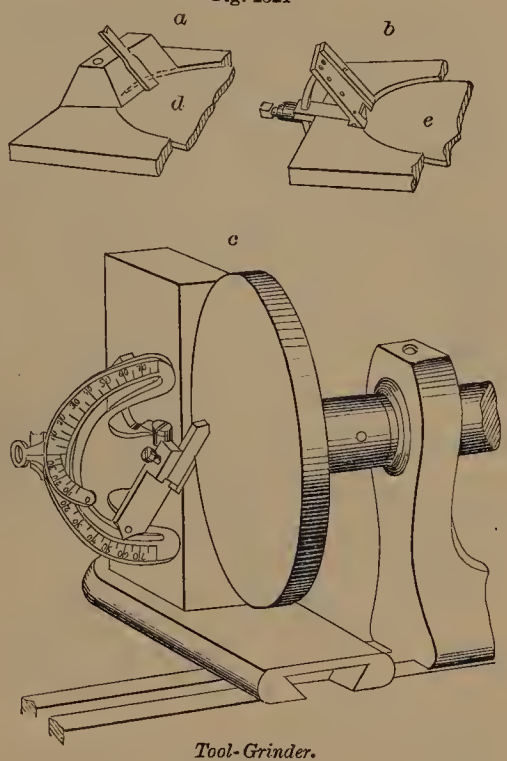
Grind'stone. Grindstones are made from the more compact sandstones, varying in texture and compactness according to the work required. Those

Fig. 2320.



Grinding-Wheels.

Fig. 2321



Tool-Grinder.

of England are highly esteemed. Different localities of that country afford such as are required for almost every purpose. Among these the "Newcastle" stones, from the coal measures of Northumberland and the adjacent counties, have a pre-eminence in England for general purposes; others are used for grinding, while many varieties are employed as plane surfaces for whetstones. Other qualities are used for hones. A German variety is famous for this purpose. The very finest qualities, composed of an almost impalpable agglutinated powder, are used as oil-stones. Such are the "Water of Ayr," and "Blue" stones, and the "Turkey" oil-stone. The old "Royal Exchange" of London was paved with this stone, and when it was burned, about 1834, the pavement yielded a handsome amount towards the re-erection.

The Nova Scotia and Berea, Ohio, grindstones are largely employed in this country; these may be obtained of very large size and uniform quality. The Washita, Arkansas, stone is of the very finest quality, being sharp and clean, and is made into a great variety of forms; grindstones, whetstones, hones, and slips of various sizes and forms.

In dressing rough grindstones, the process of hacking is employed. *Hacking* consists in notching the projecting parts with a short-handled hammer resembling an adze. *Laps* used in polishing stones, etc., are *jarred* by holding an old knife against their edges, so as to vibrate or *chatter*, making a slight indentation at each jump; these serve to retain the finely powdered emery or rottenstone mixed with adhesive material with which the lap is covered.

For clearing the surfaces of stones, in which particles of iron or steel have become imbedded, a square bar of $\frac{1}{2}$ to $\frac{1}{4}$ inch iron is held and wabbled against the edge while in motion. This is called *straggling* or *ragging*.

Turning or *roving* is effected by reversing the motion of the stone and holding a hooked flat tool against its edge, which is afterwards farther smoothed by the roving plate.

The series of operations in making grindstones is about as follows.

The layer or ledge of rock being uncovered, channels are cut at each end of the slab to be removed, and then a row of holes is drilled on the line where the fracture is to be made. Steel wedges are driven into these holes, driving them consecutively a little at a time, keeping all on a strain, until the mass cleaves from the ledge forming a large parallelopiped. This block is similarly divided into squares, and these, if too thick, are split or cleft in the plane of the stratum to thickness required.

The square stone is now chipped into an octagonal shape, when it is ready to have the eye made. This is done by a pick-hammer.

It is then mounted on a mandrel driven at the rate of 125 rotations a minute. The turning-tools are five feet long, one and a half inches wide, and five eighths of an inch thick, tapered to a point by the blacksmith and afterward hammered to a hooked point by the workmen, who turn from 100 to 200 per day, according to size. An exhaust-fan withdraws the stone-dust, and a conductor leads it to the outside of the building.

The stones are placed in a row, an iron rod and wooden axis through them, a wooden head at each end being jammed against the stones by nuts. Slats nailed to the wooden heads and hoops over the slats complete the package. The works at Berea, Ohio, are the largest in the United States.

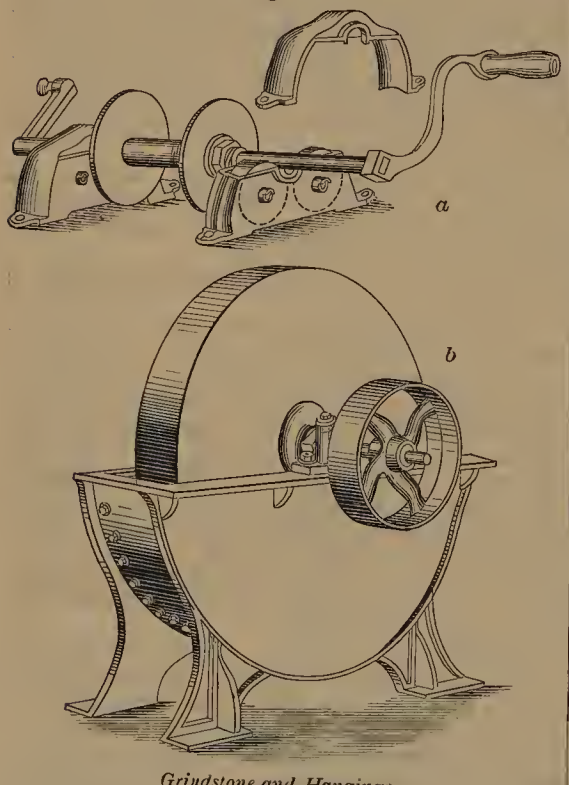
The large grindstones employed in grinding gun-barrels are 8 feet in diameter, and are used until they are reduced to a diameter of about 2 feet, when they are rejected. They are placed in a case with holes for the introduction of the barrel, which is temporarily slipped upon a rod, a crank at one end of the latter enabling the barrel to be turned while the stone is rapidly revolved. The case keeps the water from splashing upon the workman, and may afford some protection against pieces when the stone bursts, as it sometimes will, owing to the rapid rate at which it is driven. The danger of fracture cannot be entirely obviated, but may be much lessened by clamping the stone on its axis by disks instead of wedges inserted between the sides of the eye and the square arbor on which it it suspended. It would seem possible to avoid the eye altogether, and depend upon cheek-pieces with studs or projections which penetrate into depressions in the sides of the stone. The stones are so very heavy that their fracture when in rapid motion is apt to do great damage to life, limb, and property.

Artificial stones are largely employed, especially in dry-grinding and polishing.

The *corundum stone* used by the Hindoos and Chinese is composed of corundum powdered, 2 parts; lac-resin, 1 part. The two are intimately mixed in an earthen vessel, kneaded, flattened, shaped, and polished. A hole for the axis is made by a heated copper rod.

The grain is more or less fine, according to the grade of the powdered corundum. The wheel is

Fig. 2322.



Grindstone and Hangings.

mounted horizontally, and revolved by a bow in the right hand of the workman, while the left applies the work to the stone.

The following recipe may also be employed:—

Sand of the required fineness, 3 or 4 parts; shellac, 1 part; melted, incorporated, and molded under pressure.

Ransome's artificial stone, sand agglomerated by silicate of lime, has been used for grindstones with excellent effect.

In a test trial between Ransome's (English) artificial grindstones and some Newcastle grit to ascertain which had the greatest abrasive effect, it was found that the Ransome stone ground away ¼ ounce from a steel bar ¾ inch diameter in sixteen minutes, while a Newcastle stone (natural grit) driven at twenty per cent greater speed required eleven hours to effect the same work. (London "Engineer.")

a, Fig. 2322, illustrates an arrangement for hanging grindstones in which the stone is held between adjustable disks and journaled between anti-friction rollers.

b, Fig. 2322, is an improved form of grindstone stand, having a pulley for turning, a lubricating oil-cup, and side-disks for holding the stone.

Stones for grinding cutlery vary in diameter from 4 inches to 2 feet. The faces of some, as of those for grinding razors, are convex. Those for dry grinding, an operation very injurious to health, have a flue above through which the small particles of stone and metal are driven by an air-blast.

Magnets have also been placed near that portion of the periphery of the wheel where the work is applied, in order to attract the filings, which would otherwise be inhaled by the workmen.

The angles formed by the faces of cutting-tools increase in proportion to the hardness of the material to be operated upon. Thus, the razor has an angle of from 17° to 20°, wood-cutting tools 25° to 45°, and tools for iron and steel 60° to 70°. For reaming-tools the angles are greater; for the hexagonal broach, 120°; octagonal, 135°.

Great care should be taken, where tools requiring an accurate edge are to be ground, to keep the face of the stone true. This may be effected by hanging a pair of grindstones so that their faces shall touch. Their rotation thus causes each to wear away the inequalities of the other.

The teeth of circular saws may be sharpened by a small grindstone having on the edge a ridge suited to the form of the teeth, and a slide fitted with an adjustable stop to regulate the abrasion.

Gripe. 1. (*Nautical.*) *a*. The *fore-foot* of a ship, on to which the *stem* is planted. The forward end of the *keel*. It is scarfed to the stem-piece and false-keel, and is secured by a horseshoe or ring to the stem. See STEM.

b. A broad plait of rope or bars of iron with lanyard rings and claws, passing over a large boat and by which it is secured to the ring-bolts of the deck.

c. One of a pair of bands passing round a boat near the stem and stern when suspended from the davits to prevent the boat from swinging about.

2. A brake applied to the wheel of a crane or derrick. It generally consists of an iron hoop under the control of a lever, and is drawn closely around the wheel to check its motion.

3. (*Weapons.*) Of a sword-hilt. The part which is grasped by the hand.

Grip'pers. (*Printing.*) The fingers on an impression cylinder which seize the paper by one edge and carry it to, and sometimes through, the press. In some cases tapes conduct it after it has been fed in by the grippers.

Grist. 1. (*Rope-making.*) A given size of rope. *Common* grist is a rope 3 inches in circumference, with twenty yarns in each of the three strands.

2. (*Milling.*) A batch of grain to be ground in a custom mill, or the result of the grinding less the toll.

Grist-mill. A grain-grinding mill. See GRINDING-MILL.

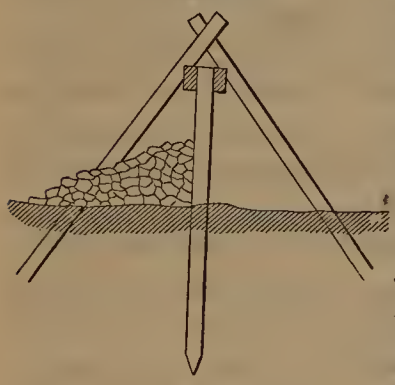
Grit. A sandstone used for grinding. The term *millstone-grit* shows that it was the material used in grinding-mills, but its use now is principally for *grindstones* and *whetstones*, *buhr* being used for *millstones*. *Buhr* is a foraminous quartz.

Gro'gram. (*Fabric.*) A coarse stuff of silk, or silk and mohair. The name is French (*gros-grain*, coarse texture).

Admiral Vernon, 1750, introduced rum and water as a ration on board ship, and wore a *grogram* coat. The soubriquet *Old Grog* referred to the coat, but was afterwards applied to the beverage.

Groin; Groyne. 1. A timber structure on a beach to accumulate shingle and sand, so as to form an advance protection from the energy of the waves to the land situate in its rear. It is formed of piles driven into the beach and projecting above it, to which are fastened land ties and planking. The illustration shows an open framing of timber placed parallel to the shore on the line of low water, and common in Holland. To avoid the washing out of the sand by the reflux of the wave, an apron of stone is placed at the foot.

Fig 2323.



Groin.

On the Sussex coast, south of England, the groins are from 150 to 250 feet long. The piles 4 feet apart, 12 to 25 feet in length. Planking 2½ inches thick; land ties 25 feet in length. Every 16 feet in length contains 4 piles, 1 land tie, tail piles and keys, tie bar, blocks, and bolts, 180 superficial feet of planking, 140 6-inch spikes, and costs $150. See Sea-wall; Breakwater.

2. (*Architecture.*) The line of junction of two intersecting arches. A *Welsh* groin is one crossing transversely, but having a lesser pitch or hight.

Groined Arch. (*Architecture.*) An arch intersected by another cutting across it transversely. The line of junction is the *groin*.

Groin-rib. (*Architecture.*) A rib or projecting member following the line of junction of the two arches forming a groin.

Grom'met. 1. (*Nautical.*) A ring formed of a strand of rope laid round and spliced. Used as a *hank*, a *thimble*, or with large oars, in connection with a pin, as a substitute for a row-lock. Metallic grommets, forming eyelets, are sometimes substituted. In the example, an iron flange is cast to the wrought-metal thimble; after insertion the edge is spun over upon the other cast-metal ring.

Fig 2324.

Grommet.

2. (*Ordnance.*) A wad made of rope, rammed down between the ball and the charge. Made of oakum and bound with spun-yarn, it is called a *junk-wad*.

Groove. 1. (*Joinery.*) A channel in the edge of a board. In *matched* boards it receives the *tongue*.

2. (*Guns.*) A spiral channel between the lands in rifling.

Grooved Bit. A wood-boring tool adapted to be used in a brace, and having a cylindrical stem with a spiral groove. See Bit.

Grooved Wheel. 1. One having circumferential indentations, as a mode of increasing the traction or effective frictional surface contact. The edges of corresponding wheels have counterpart channels and ridges, so as to increase the area of the contacting surface and allow them when driven against each other to attain a mutual *bind* or *grip*. A *friction-wheel*. The two constitute a *friction-gearing*.

Fig. 2325.

Grooved Wheels.

2. A band-wheel or pulley having peripheral depressions for a round band, as in some lathes.

Groove-ram. (*Needle-making.*) A stamp for making the groove in which the eyes of needles are formed.

Groov'ing-planes. Carpenters' and joiners' planes which are adapted for cutting grooves, such as the *plow*, *fillister*, *router-plane*, *banding-plane*, etc. (which see). Planes are made in sizes to suit, in pairs known as *hollows* and *rounds*.

Gros. (*Fabric.*) A heavy silk with a dull finish.

Gros-de-Na'ples. (*Fabric.*) A plain, heavy, woven fabric, made of organzine silk.

Ground. 1. (*Navigation.*) To touch bottom.

2. (*Fabric.*) The prevailing color.

3. Sediment.

4. (*Plastering.*) Flush strips in plastering for the attachment of moldings and other finishing.

5. The surface of the ground, level or otherwise, or a representation thereof; as, —

Ground plan. Ground plane.

6. The parts of a foundation or of a structure near the base; as, —

Ground-joist. Ground-sill.
Ground-plate. Ground-work.
Ground-plot.

7. (*Painting.*) The color first laid on.

8. (*Japanning.*) The pigment mixed with hard varnish which forms the basis for the japan or polished varnish surface.

9. (*Engraving.*) An acid-resisting composition of, asphaltum, 4; Burgundy pitch, 2; white wax, 1. This is melted and mixed, and then tied up in a silk rag.

In using, the plate is heated over an alcohol lamp or brazier, and the composition smeared on. It is then spread by a silk dabber, and blacked by the smoke of a candle or an oil-lamp. When cool it is ready for the *etching-point*. See Etching.

Where the point removes the ground, the plate is exposed to the subsequent action of the acid, and a line or a dot, as the case may be, is made in the plate.

Soft-ground is made by adding 1 part of lard to 3 parts of common etching ground. It is used for a certain kind of etching called *etching on soft ground*. See Etching.

In mezzotint engraving, the *ground* is said to be *laid* when the whole face of the plate to be occupied by engraving is raised by the *cradle* so as to have a *burr* which would print a uniform black. This is scraped away for the lights. See Mezzotint Engraving.

10. (*Telegraphy.*) *a*. Accidental connection between the line wire and the earth.

b. The earth in its capacity as the return-circuit carrying body. The wire is carried to earth and connected to a *ground-plate*, or in cities to a water or gas main, which forms an admirable and extensive conductor.

Ground-au'ger. An earth-boring auger. See AUGER. Figs. 441–443.

Ground-glass. Glass whose surface is *ground*, so as to break up the pencils of light passing through it, preventing the passage of a distinct image. Lamp globes are ground in order to mellow and disperse the light passing through them. The process is done mechanically or chemically; the wheel, sand-blast, by rotating with pebbles inside, or by fluoric acid.

Ground'ing-in. The application of the secondary and subsequent colors to a cotton cloth, after it has received the color of the first block. It is a term used in the hand-block printing, and the *grounding-in* or *re-entering* may be of a *mordant*, a *topical-color*, or a *resist*. The correspondence of position of the color in the pattern is secured by points on the block; equivalent to the *register-point* of the chromatic process of type-printing or lithography.

Ground'ing-tool. (*Engraving.*) The rocker by which the mezzotint steel plate is roughened.

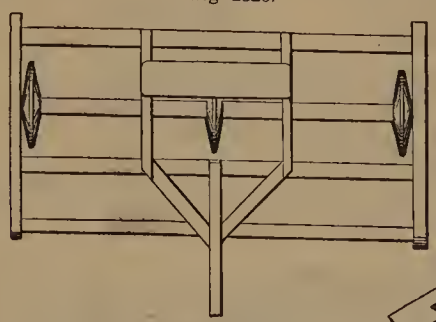
Ground-joint. A joint made by grinding together two pieces of metal with emery and oil; or pieces of glass with fine sand and water: the glass stopper is a specimen of the latter.

Ground-joist. (*Carpentry.*) A joist of the basement or ground floor. Often termed a *sleeper*.

Ground-lay'ing. (*Porcelain.*) A coating of boiled oil to the surface of porcelain, in course of manufacture, to receive the color. *Bossing.*

Ground-mark'er. An implement for laying off corn-rows. It is frequently attached to a corn-planter to make a mark for planting on the next bout. In the example, it is a frame with three sharp-rimmed wheels set at the desired distance apart, say 3 feet 8 inches to 4 feet, according to the size of corn and the practice of the country. The "King Philip" corn of New England may do with

Fig 2326.



Ground-Marker.

36 inches, but the larger Southern varieties need 48 inches apart in the rows and between the rows.

Ground-mold. (*Civil Engineering.*) A templet or frame by which the surface of the ground is brought to the required form, as in terracing or embanking.

Ground-plan. A representation on a horizontal plane of the foundation, or of the arrangement of the lower tier of rooms of a building.

Ground-plate. 1. (*Building.*) The lower horizontal timber of a building on which the frame is erected. *A sill.*

2. (*Railway Engineering.*) A bed-plate for sleepers or ties in some kinds of ground.

3. (*Telegraphy.*) A metallic plate buried in the earth to conduct the electric current thereto. It should bear a certain proportion to the size of the conductor which is attached to it; it should have a surface as many times larger than the surface of the conductor as the difference in the conductivity of the conductor and the earth. Connection to the pipes of a gas or water main is usual in cities.

Ground-plot. A representation on a horizontal plane of the ground to be occupied by a structure or other engineering works.

Grounds. (*Carpentry.*) *a.* Pieces of wood nailed on as guides for the plastering which comes flush with the face of the *grounds*. To them the molding and other finishings are nailed.

b. Framing or pieces forming a basis for other structure, as *ground-sills*.

c. Sheathing upon *quarters* or *studding* to form a basis for cornice work or moldings.

Ground-seat. (*Saddlery.*) A ply of canvas or linsey drawn over the *straining* which supports the padding and seat of a saddle.

Ground-sill. (*Carpentry.*) A *sleeper;* or a lower timber, which supports the remainder of the frame.

Ground-table. (*Building.*) The foundation course of stones.

Ground-tack'le. (*Nautical.*) The ropes and tackle connected with the anchors and mooring apparatus.

Ground-tim'bers. (*Shipbuilding.*) Those which lie on the keel and are bolted to the keelson. *Floor-timbers.*

Ground-ways. (*Shipbuilding.*) The large blocks and planks which support the cradle on which a ship is launched.

Ground-wheel. That wheel of a harvester which, resting on the ground, is revolved by con-

Fig. 2327.

Ground-Wheel.

tact therewith when the machine is at work, and which drives the cutter.

Similar wheels in other agricultural wheeled implements actuate subsidiary parts, such as the feed-wheels of drills, the thrashing cylinders and shoes of traveling harvesters, the rakes of hay-loaders, the reels of tedders and reapers, etc.

Ground-work. 1. (*Civil Engineering.*) *a.* The preparation of ground for the foundation of a structure, or giving it the required contour for any other purpose.

b. The basis or structural foundation of an erection.

2. (*Painting.*) The base color on which the painting is performed.

Grout. *a.* A thin coarse mortar used to run into crevices between the stones or bricks of a structure. "The Norman walls were of great thickness, and were filled up with small stones, amongst which mortar was poured in hot. This was called *grouting;* and in time the whole mass so hardened to-

gether as to acquire the consistence and strength of a solid rock." — WEALE.

b. A finishing or setting coat of fine stuff for ceilings.

Grove Bat'ter-y. A form of double-fluid galvanic battery, invented in 1839 by William Robert Grove, F. R. S. It has a glass jar or cell in which is placed a plate of zinc bent into cylindrical form, and thoroughly amalgamated. Within the zinc is a porous cup, in which is placed a strip of platinum.

In the outer cup is dilute sulphuric acid (1 of acid to 20 of water by measure), and in the inner or porous cup is strong nitric acid. See GALVANIC BATTERY.

Grow'ing-slide. A cell formed between two glasses, adapted as a *slide* for a microscope, and supplied with water by the capillary action of a few filaments of cotton extending thence to a little reservoir of water. It is designed for preserving algæ or infusoria in a growing condition.

Groyne. (*Hydraulic Engineering.*) A projecting defence extending out from the sea-shore or bank of a river, to prevent the land from being washed away. A shingle-trap. See GROIN.

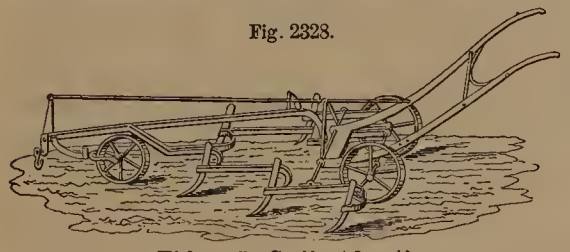
Groz'ing-i-ron. 1. An instrument with an angular steel projection, used for cutting glass before the general application of the diamond to that object.

2. (*Plumbing.*) A tool used in smoothing the solder joints of lead pipe.

Grub'ber. (*Agriculture.*) *a.* An agricultural implement used in Scotland for stirring and loosening the soil to plow depth. It is a heavy cultivator drawn by four horses, and supported on wheels. One form has an inner frame attached to the wheel-frame, and has two ranks of teeth, 5 in the front and 6 in the rear, cutting the balks between the preceding and outside of them. The teeth consist of colters armed with shares.

The form represented in Fig. 2328 is a heavy implement, not designed for tending crops, but to bring

Fig. 2328.



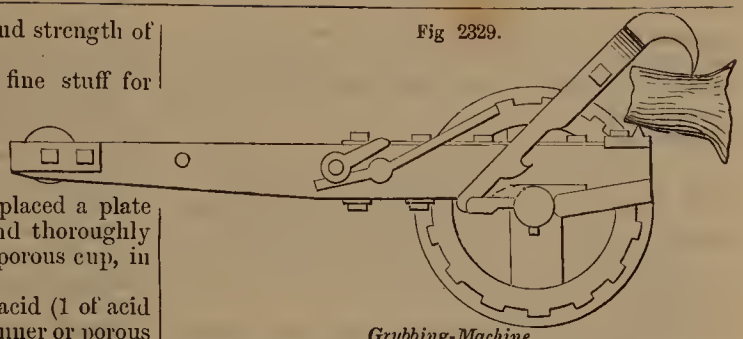
Kirkwood's Grubber (Scotch).

the land to a state of fine tilth, acting as substitute for the plow in some cases. It is more the practice in Britain than in the United States to give several successive plowings to ground in the course of one season, before sowing the seed. The grubber and some others of the heavier forms of cultivators are thus used. We apply the tool to the crop principally; they to that purpose, and also to the land, stirring it to bring it into good order and tilth before sowing.

The grubber represented has a frame of a general triangular shape, having teeth set in divergent rows. It has a caster-wheel in front and two wheels behind. The machine is adjusted vertically, by means of depressing the handles, which oscillate upon the hind axle and raise the share frame, being attached to a transverse bar across the frame near the rear and to the lever in front, which forms the carriage of the caster-wheel. This is a highly respectable implement.

The term "grubber" is somewhat local, and other implements of similar construction and purposes are described under CULTIVATOR (which see).

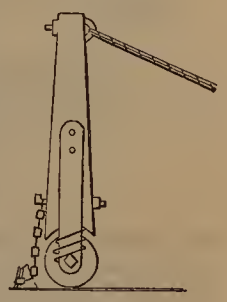
Fig. 2329.



Grubbing-Machine.

b. A machine or tool to pull *grubs;* that is, stumps and roots of bushes, saplings, and small trees. Some heavy plows are made to tear through ground occupied by the stubs and roots of bushes and brush. The English *turn-wrest plow* is adapted for tearing through and routing up the roots of bushes. The grubber shown at Fig. 2329 has a lever supported upon an axle and wheels. When in vertical position it is attached by a grab hook and biting tooth to the stump, the lever is then pulled over by a rope or tackle, as seen in the smaller figure (Fig. 2230), where a post, roller, and chain constitute the apparatus. The pole is attached by the hounds to the axis of the rollers when being transported, but presses directly on the periphery of the roller when in action.

Fig. 2330.



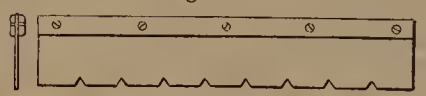
Grubber.

Grub'bing-axe. An implement having a curved bit presented at right angles to the helve, like an adze; and another bit presented in the line of the helve, like an axe. A *mattock.*

Grub'bing-hoe. A heavy hoe for digging around stumps or stones. A mattock.

Grub-saw. A hand-saw used for sawing up marble slabs into strips, such as shelves, mantelpieces, etc. The kerf is started by a narrow chisel

Fig. 2331



Grub-Saw.

while lying upon the rubbing-bed. It has an iron blade notched at the edge, and stiffened by a backing of wood like the metallic back of a tenon-saw.

Grunt'er. (*Brass-founding.*) An iron rod, with a hook at the end, by which an assistant aids in supporting the crucible, by catching hold of the shoulder of the crucible-tongs.

Gua'no-sow'er. Guano is the excrement of sea-birds collected in thick beds on some islands on the coast of Peru, and in some other places. Its use is no new thing. The Peruvians before the conquest used guano in the cultivation of the potato, tobacco, corn, and other plants for which Europe is indebted to this side of the Atlantic. An English cruiser in 1720 mentions having captured a small vessel laden with it.

The guano-sower is sometimes an attachment to a wheat-drill, and does not differ very materially from a seed-sower, except in devices to keep the stuff stirred up and prevent its becoming aggregated in lumps.

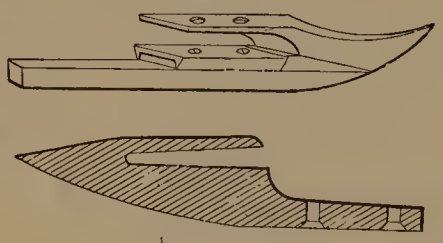
Guard. 1. An upright piece of wood in a narrow passage to prevent the lock of a canal or the corner of a street from being injured by passing boats or vehicles. A *fender*, *guard-pile*, or post, as the case may be.

2. (*Navigation.*) An extension laterally of the deck of a river steamboat, beyond the lines of the hull, making it overhang the water. It frequently comes flush with the outside of the paddle-box.

3. (*Machinery.*) A light frame in which the nuts of bolts fit to prevent their unscrewing by the vibration of the engine.

4. (*Husbandry.*) One of the teeth projecting forward from the cutter-bar of a harvester. The knife plays through the guards, and the knife sections

Fig. 2332.



Harvester-Guards.

make a shear cut against the soles *B* of the guard-slots. In the upper figure the sole-piece is removable to enable its edge to be sharpened.

5. The bow or basket of a sword-hilt to protect the hand.

6. (*Fire-arms.*) *a.* A bow beneath a gun-stock protecting the trigger.

b. A safety-lock of a fowling-piece to prevent the accidental dropping of the hammer.

c. A nipple-shield to protect the little tube which receives the percussion-cap.

7. A bow or wire around a lantern to protect the glass.

8. (*Bookbinding.*) One of the slips of paper bound in with a blank-book to thicken it at the back, when the leaves are intended to contain mounted slips, or drawings.

Guard-fin'ger. One of the teeth projecting forward from the cutter-bar of a harvester, and through which the knife plays. See GUARD.

Guard-lock. (*Hydraulic Engineering.*) A *tide-lock*, forming a communication between a basin and tide-water.

Guard-pile. (*Maritime Construction.*) A pile of the nature of a *fender*, driven in front of a quay or wharf to protect the structure from the blows of, or abrasion by, a vessel alongside.

Guard-plate. The plate which closes the opening in front of a cupola-furnace, to whose iron casing it is attached by staples. In the center of the plate is the *tapping-hole*, through which the melted metal flows when the *stopping* is withdrawn.

Guard-rail. (*Railroading.*) 1. A short rail placed on the inside of a main rail, so as to keep a wheel on the track by pressing against the inside of the flange of the wheel. It is used when there is a short break in the continuity of the other rail, as in switches and crossings. A *safety*, *side*, or *wing* rail.

2. (*Nautical.*) *a.* A hand-rail on the paddle-box bridge of a steam-vessel.

b. A breast-rail on the break of the poop.

3. A safety-rail around a hatchway.

Gud'geon. *a.* The metallic journal piece let into the end of a wooden shaft.

b. The bearing portion of a shaft.

c. The metallic eye bolted to the stern-post to hang the rudder upon.

Fig. 2333.

Gudgeon.

The rule for finding the size of the gudgeon of a timber water-wheel is as follows: —

Multiply the diameter of the wheel in feet by the width of the wheel in feet, add to this the square of half the diameter of the wheel in feet. The cube root of the sum thus obtained will give the required diameter in inches.

Guest-rope. The rope by which a boat is kept steady while in tow.

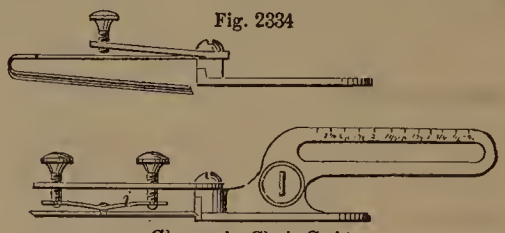
Guide. 1. A tool or instrument director, as the staff or director of a surgeon's probe or bistoury.

2. A pile driven to mark a site.

3. A pulley to direct a band in a new direction.

4. (*Sewing-machines.*) A means of directing cloth to the edge or face-plate of a gage, in making a hem or tuck.

Fig. 2334



Clemons's Cloth-Guide.

In the example, the elastic plate is attached to the gage-plate and rests upon the goods, an adjustable pressure being brought upon the elastic plate by a screw or screws in a rigid plate above, and in such a manner that it presses more upon the cloth outside of the seam than inside, and so directs the cloth against the face of the gage-plate.

5. (*Railway Engineering.*) An additional rail to keep a locomotive or car on the track in curves, crossings, or steep grades. See GUIDE-RAIL; GUARD-RAIL.

6. (*Steam-engine.*) One of the bars which keep in line the blocks on the cross-head of the piston-rod. See GUIDE-BLOCK.

7. (*Printing.*) A printer's copy-holder, which marks the line.

8. (*Water-wheels.*) A plate in the curb of a water-wheel to direct the water upon the buckets of the wheel.

Guide-blocks. (*Steam-engine.*) Metallic pieces with parallel sides fitted on the ends of the cross-head and sliding as guides on the side frames to keep the motion of the piston-rod direct.

Guide-pile. (*Hydraulic Engineering.*) A pile driven to mark out or limit the field of operation or a site.

Guide-pul'ley. (*Machinery.*) A pulley for directing or changing the line of motion of a belt, but not otherwise concerned in the transmission of motion.

Guide-rail. An additional rail, usually placed midway between the two ordinary rails of a railway track, and employed in connection with devices on the engine, carriages, or both, in preventing the rolling-stock from running off the track.

The *center-rail* gripped by horizontally rotating wheels acts as a guide-rail.

Blenkinsop's rack-rail (English patent, 1811) was used as a means of progression in connection with a spur-wheel on the engine, and not as a guide.

Following him was Snowden's middle-rack and mechanical horse. See CENTER-RAIL.

Easton's center-rail (English patent, 1825) fulfilled two purposes; its upper edge formed a rack and served, in connection with a spur-wheel on the locomotive, as a means of progression; its sides formed a guide-rail in connection with pairs of horizontally rotating rollers underneath the carriages of the train.

Kollman's English patent of 1836 has a similar guide-rail.

Prosser's guide-wheels (English patent, 1844) are set an angle of 45° beneath the truck, and have sunken rectangular faces which bear upon the inner angles of the square rails. The guide-wheel enables the flanges of the bearing-wheels to be dispensed with.

No extra rail is introduced.

The *guide-rail* gripped by horizontally rotating wheels, driven by the engine, the combination of wheels and center-rail forming the means of ascending gradients, is first found in the English patent of Vignolles and Ericsson, 1830.

Sellers's United States patent, 1835, has a similar device, and it is also used by Fell on the White Mountain Railroad in New Hampshire and the Mt. Cenis Railway, which climbs the Alpine pass, connecting St. Michel on the French side with Susa on the Italian.

A correspondent of the Hartford "Courant" thus describes it: —

"The carriages are about half the length of ours at home, with seats on each side, so that the passengers face each other as in an omnibus, and with windows at the sides, from which it is difficult to see out when one is squeezed in tight on the seat, with his back to them. The cars are also very narrow, the track being only three feet six or seven inches gage, so that they are not much more comfortable than an omnibus. The fare, first class, was twenty-five, second class, twenty-two francs, from Susa to St. Michel, the time occupied in the passage being from four to five hours.

"The locomotives of these trains are small, compact, and powerful; their trucks, as well as those of the carriages, set well in the middle, so that they can turn very short curves. The track has three rails, one elevated in the center. Besides its ordinary driving-wheels, the locomotive has two horizontal wheels which press this third rail on either side, and it is by this strong traction that the train is pulled up. The carriages have corresponding wheels for the center rail, but their only use is to keep the train on the track. Both cars and locomotive have double sets of brakes, one for the ordinary and one for the central rail, so that they can screw the cars to the track with the grip of a vise, and render it almost impossible for the carriages to run away. There is every precaution against accident; and I should only fear the snow-storms of winter, and perhaps an avalanche in some places high up, which are not roofed in.

"Our train seemed to be a huge live reptile with legs and claws, that crawled up by its own power; it literally dug right up hill, and we felt ourselves mounting, and, looking back, could see the deep incline. On the curves, where the wheels got a good grip of the rail, we moved with ease and more rapidly than on a straight pull, where the locomotive evidently labored more, and we rose more slowly. The steepest grade on the road is one foot in nine feet, but this is only for short distances. The rise of one in twelve is more common; and the least (of which any note is taken) is one in twenty-five. The curves are so short as to be startling. We seemed to turn in a space as small as an ordinary wagon could. The shortest curves are on a radius of only one hundred and twenty feet; that is, our train would run round a circle only two hundred and forty feet in diameter. Our track was all the time in sight, behind and before, running along the steep hillsides, and constantly doubling, like a compressed letter S."

Gui'don. A swallow-tailed company flag in a cavalry regiment, half red and half white, dividing at the fork. The red above has "U. S." in white. The white is below, and has the letter of the company in red. The *fly* is 3 feet 5 inches to the end of the tail; the *head* is 27 inches. The lance is 9 feet long, including spear and ferrule.

The regimental cavalry flag in the United States service has 29 inches *fly* and 27 inches *head*. The edge has a yellow silk fringe. The field is of silk, and has the arms of the United States embroidered in silk on a blue ground, with the number and name of the regiment in a scroll under the eagle.

Guil-loche'. (*Architecture.*) An ornament of intertwisted bands or interlaced cords, which is made continuous as a fascia.

Guil'lo-tine. A machine for beheading persons, named after Joseph Ignace Guillotin, a French physician (1738 – 1814), its supposed inventor. He did not invent it, but seeing that his Revolutionary friends had a large job of killing on hand, he suggested its use as a certain and complete mode of decapitation.

Dr. Antoine Louis, of Paris, had the credit of its invention for a while, and it appears under the hands of the facile French to have attained a completeness in construction and execution which left nothing to be desired — except, perhaps, mercy.

A beheading machine, called the *maiden*, and sometimes the *widow*, by the *lively* Scotch, was imported from Halifax, England, into Scotland, about 1550, by the Regent Morton, who seems to have been enamored of the maiden's business capacity. He was beheaded thereby in 1581, — though he was not the first victim, as has been sometimes stated. The murderers of Rizzio were beheaded by it in 1566; and among its last victims was the Earl of Argyle, 1681.

It is laid up as a memorial in the Museum of the Scotch Society of Antiquaries, Edinburgh.

Of the Halifax machine we know but little except that Morton imported the maiden thence.

Pursuing the back track, we find that the Duc de Montmorenci (blue blood) was executed by a falling axe at Toulouse, 1632; that the Dutch used it in executing slaves in their colonies, and that its use was comparatively common in Germany during the Middle Ages.

The *Mannaia* of Italy, by which Conradin of Swabia was executed, 1268, at Naples, and Beatrice Cenci at Rome, in 1605, was of the same construction substantially.

The guillotine is mentioned in German books of 1534, 1551, and 1570. It is called the Roman falling-axe, and the decollation of St. Matthew thereby was a favorite subject with illuminators of manuscripts 250 years before the French Revolution.

In the London "Monthly Magazine," April 1, 1800, p. 247, is an enumeration of ten cuts and engravings of the sixteenth century in which a guillotine is employed. The representations are principally martyrdoms of saints.

During the war of the Spanish Succession, 1702 – 13, Count Bozelli was decapitated by the guillotine, which is thus described by a traveler who witnessed the act: —

"In the great square was erected a scaffold, covered with black. In the middle of it was placed a

great block of wood, exactly of such hight that the criminal, on his knees, could lay his head upon it, between the pillars of a sort of gallows, which supported an axe of a foot in hight and a foot and a half in breadth, sliding in a groove. The axe had a mass of above a hundred weight of lead attached to its upper side, and was suspended by a cord fastened to the gallows. The executioner cut the cord that supported the axe. The deadly instrument in its fall severed the head from the body, and penetrated about two inches into the block."

Fig. 2335.

Guillotine.

The original instrument was probably Persian.

The French *guillotine* has a heavy knife, sliding in vertical grooves in a frame.

It is a grim subject, but, involving mechanical construction, is within our scope.

An observer in Paris thus records the appearance of the machine and the mode of using it: —

"On a platform about 12 feet square, and 7 feet above the ground, are erected the two upright posts between which is suspended the axe. They somewhat resemble a narrow gallows with not more than a foot between the posts. The axe, which is not unlike a hay-knife, though much heavier and broader, is drawn up to the top of the posts, between which it runs in grooves, and is held suspended by a loop in the halyards, passed over a button at the bottom. The edge of the axe is diagonal, so as to make a *draw* cut, giving it a fearful power and certainty in severing a human neck.

"On the center of the platform stands a frame or large inverted box, much resembling a soldier's arms-chest, about 6 feet long and 2½ feet wide and high. One end of this abuts upon the upright posts; at the other end is a small truck having a strap and buckle by which the culprit is secured to it.

"The victim was advanced with his breast against the truck, to which his body was rapidly strapped. He was then tilted down, truck and all, upon his face; the truck, moving upon small wheels in grooves on the top of the chest, was run rapidly forward until the neck came under the knife. The rope was unhooked from the button, the axe fell with a *thud*, the head fell into a basket, and the body was unstrapped and rolled into a large basket alongside."

There is an air of ferocity about the punishment by beheading, and of absolute brutality in the mode of execution by hanging. The Japanese are skillful decapitators. The Spanish garotte is a horror. Poisoning is ancient but disreputable. Shooting is martial, and has one merit; it enables a man to stand up and face the executioner, and has less of humiliation than the cutting and choking processes.

It is a vulgar error that Dr. Guillotin perished by the machine of his suggestion. He died in 1814, after founding the Academy of Medicine.

The myth seems to have been derived from the Regent Morton's having been beheaded by his imported pet. This kind of poetic justice is commoner in tradition and romance than in fact. It seems to round up and complete the history when —

"This even-handed justice
Commends the ingredients of our poisoned chalice
To our own lips."

"Where the offence is let the great axe fall."

Guil'lo-tine'-cut'ter. A machine which cuts by a knife descending in guides. Cutters for paper and straw are thus made, and the descent is usually oblique, so as to give a *draw* cut.

Gui-pure'. A kind of lace in imitation of the antique. Patterns are cut out of cambric to form the flowers and heavy parts; the open parts are made of stitches.

Gui-tar'. The ancient Egyptian guitar (*a*, Fig. 2336) had a hollow, oval body, and its upper surface was perforated for the escape of the sound. It had three strings of catgut, fastened at the lower end to a triangular piece of wood or ivory which raised them to a sufficient hight without a bridge. The guitar was played as an accompaniment to the voice and in concert with other instruments. Also in concert with dancing motions and posturing, which is about as near as the Egyptians came to theatrical performances. These were invented by the Grecks, the originators of tragedy and comedy. The Romans added the pantomime.

On the Guglia Rotta at Rome is a large obelisk, which was brought from Egypt by Augustus and thrown down and broken at the sacking of the city by the Constable of Bourbon, in 1527.

On it is represented a guitar (*b*) which had evidently two strings. The length of the finger-board would allow a considerable scale of notes.

In the sculptures of Nimroud is represented a musician playing on a guitar.

The present name is derived intermediately from

the ancient Greek, where it indicated a musical instrument resembling a harp (*cithara*).

The Europeans, ancient and modern, derived it from Egypt. Like some other things, it was imported directly into Greece from Egypt in ancient times; and again through the intervention of the Saracens into Europe, after the lull of the dark ages; following the track through Spain.

The modern Arabs have an instrument called the 'ood (*e*, Fig. 2336), which may be considered the Syrian guitar. The head is bent over as in the Euro-

Fig. 2336.

Guitars.

pean guitar; the neck appears to be destitute of frets. The strings are seven, and are made of catgut.

The Peruvians had a guitar with five or six strings, called a *tinga*. They also possessed the *syrinx*, *flute*, *tambourine*, and *trumpet*.

The guitar was introduced into England by Francis Corbeta, about 1660, and was a novelty to the writers of the day.

"I heard a Frenchman play upon the guitar most extreme well, though at best methinks it is but a bawble." — PEPYS's *Diary*, 1661.

"My Lord Sandwich playing upon the gittarr, which he now commends above all musique in the world." — PEPYS's *Diary*, 1665.

The guitar is the principal musical instrument of the Japanese. Their *syamsie* has three strings, two in the octave, the middle one giving the fifth. It is played with a plectrum, consisting of a flat piece of horn, held between the thumb and third finger. The Japanese have no idea of harmony, and play all their instruments in unison. Their dancing is of the Oriental style, like the Almehs of Egypt, — motions of the arms, head, and body, rather than of the feet. It is not so exclusively professional as in Egypt and India, and consequently not so systematically lascivious.

The Spanish guitar *d* has a hollow body with a round opening in the sounding-board. The neck has seventeen frets. The strings are six, are tuned E, A, D, G, B, E, and are stretched between a bar attached to the sounding-board and the pegs, which are journaled in the *head*.

An English guitar has been constructed to be touched by keys, and one of a large size has been made in Germany, and is adapted to be held with the bow between the knees. Neither have proved valuable accessions to the list of musical instruments.

Gui'tar-ban'jo. An instrument combining the characteristics of the guitar and the banjo, having the strings and fretted neck of the former, and the sheepskin head and metallic hoop of the latter.

Gul'let. 1. (*Civil Engineering.*) A narrow working cutting made in the formation of an excavation, and used as a means of laying down a pair of rails to bring the dirt-cars to the bank.

2. (*Harness.*) The lower end of a horse-collar, around which passes the *choke-strap*, and the *breast-strap* which supports the pole of a carriage.

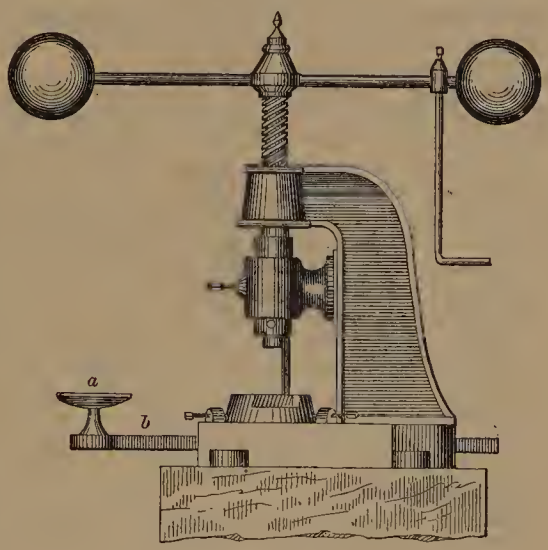
3. (*Saws.*) A hollow cut away in front of each saw-tooth, in continuation of the face, on alternate sides of the blade. Such saws are known as *gullet-saws* or *brier-tooth saws*.

The gullet is adapted to allow the saw to be sharpened by a round or half-round file, by which the face of the tooth becomes concave when viewed edgeways, and acquires a thin cutting edge. The increased curvilinear space also allows more room for the sawdust. See GULLET-SAW.

Gul'let-ing. (*Railroad Engineering.*) In excavating for railroads, a system of carrying the work forward in a series of steps upon which different gangs of men are at work with pick, shovel, and wheelbarrow, assisted by temporary lines of rail and dumping-wagons if the work be sufficiently extensive. Also called *notching*.

Gul'let-ing-press. A press for punching or gulleting saw-blades, gumming worn saws, or paring

Fig. 2337.

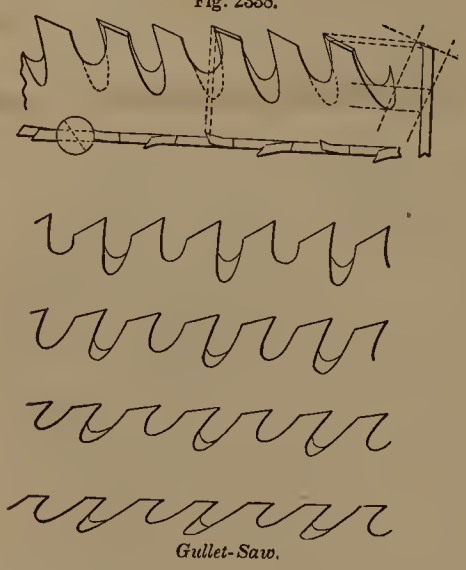


Gulleting-Press.

down or retoothing broken saws. The punch is socketed in the end of a plunger whose upper portion is a double-threaded screw crowned by a fly-handle. The table *a* is adjustable by means of its rod *b*, and affords an axis for the eyes of circular saws or saw-blades under treatment.

Gul'let-saw. A saw having a hollow cut away in front of each tooth in continuation of the face and on alternate sides of the blade. Called also a *brier-tooth saw*.

Fig. 2338.



Gullet-Saw.

Gul'let-tooth. A form of saw-tooth. See GULLET-SAW.

Gul'ley. The tram-plates or rails laid for the use of tram-wagons.

Gum. 1. An instrument for shaping saw-teeth. See SAW-GUMMER.

2. A hive made of a section of a hollow log; a *bee*-gum.

3. A hollow log inserted vertically into the ground as a curb for a spring.

4. A vegetable secretion which hardens as it exudes, but is soluble in water; distinguished from resins, which are soluble in alcohol, but not in water. There are a few resins which by careless custom are named as gums, such as *copal*, often called *gum-copal*.

Gum'mer. A tool or machine for deepening and enlarging the interdental spaces of worn saws. See SAW-GUMMER; GULLETING-MACHINE.

Gum'ming. (*Lithography.*) The treatment of a lithographic stone with a solution of gum-arabic, after, or simultaneously with, the etching process, whereby the clean parts of the stone devoid of work are protected from receiving fatty matter, and thus reject the greasy ink when the roller passes over the stone. The clean surface of the stone is damped between each impression, but, without the gumming, it would not permanently resist the ink.

Gum-pot. A copper boiler used by varnish-makers for melting the gum and mixing the ingredients. It is about 33 inches deep, and 9½ inches in diameter. An upper section is riveted to it to keep in the ingredients when they foam. It is supported by a circumferential flange which rests on the top of the furnace, and is adapted to be readily removed and replaced.

Gun. A weapon having a barrel adapted to receive and discharge a missile which is projected by a charge of powder, gun-cotton, or air, as the case may be. See under the following heads: —

Air-gun.	Fire-arm.
Arquebus.	Fowling-piece.
Battery-gun.	Gatling-gun.
Blunderbuss.	Howitzer.
Cannon.	Machine-gun.
Carbine.	Magazine-gun.
Carronade.	Mitrailleur.
Columbiad.	Musket.
Field-gun.	Pistol.
Pivot-gun.	Siege-gun.
Revolver.	Swivel-gun.
Rifle.	Steam-gun.
Shot-gun.	

Allied are another class not usually termed guns.

Mortar.	Coehorn.

The projectiles are numerous. Lists may be found under WEAPONS; PROJECTILES; FIRE-ARMS; ARTILLERY (which see).

Gun-bar'rel. Gun-barrels of superior quality are known as *stub*, *stub-twist*, *wire-twist*, *Damascus-twist*, *stub-Damascus*.

Stub-iron consists of horseshoe nails, cleaned in a tumbling-box, mixed with from 12 to 50 per cent of steel pieces of the same size; puddled, hammered, heated, tilted, and rolled. From this material a *skelp* is made.

Twist barrels are made of a ribbon of iron wound spirally around a mandrel and welded.

Stub-twist is stub-iron coiled on a mandrel, as described.

Wire-twist is made by welding laminæ of iron and steel together, or two qualities of iron, and drawing the compound bar into a ribbon, which is coiled as described.

Damascus-iron is made of several bars of steel and iron laid parallel in a *fagot* and drawn out into a bar. A piece of the bar is heated to redness, one end placed in a vise and the other end grasped by tongs, by which the bar is twisted till it assumes a cylindrical shape, and is shortened to, say, three feet. Several such bars, twisted in diverse directions, are laid together, welded, and drawn into ribbons, which are severally wound on mandrels as before.

Stub-Damascus is formed from a single bar or twisted rod, forged, drawn into a ribbon, and wound on a mandrel.

Damascus and wire twist is ribbon of the said varieties combined.

The ribbon for the twisted barrel is several yards long, about ½ inch broad, and is thicker at one end than the other, in order to give the strength at the breech. It is heated to redness, coiled around a mandrel, the coil removed, heated to welding heat, dropped on to a cylindrical rod which is then struck vertically on the ground to jar the edges of the spiral together and cause them to adhere. This is called *jumping*, and the operation of welding is completed by a hammer on an anvil, the central rod being maintained in position.

The iron plate, technically termed a *skelp*, is usually about a foot in length, and when heated to a welding temperature is rolled around a mandrel and passed through sets of rollers, which, in turn, elongate the skelp, reducing its diameter and giving the proper size and taper to the barrel.

Formerly the edges of the heated blank were welded upon the mandrel by the successive blows of a trip-hammer, or a "drop," dies intervening between the iron tube and the drop and anvil respectively. A portion only of the seam is closed at a time by this means, and the operation is more tedious and expensive than the rollers just described. The rolling process was introduced from England.

(*Boring.*) For boring, the barrels are placed in a heavy iron frame called "boring banks," where they are reamed out by the boring-tool, which consists of a square broach of steel, with sharp edges. The tool is rotated and advanced while the barrel is firmly held, and the operation is repeated with successively larger tools until the required size is obtained, — something short of the eventual caliber, as

other operations are to follow, and will farther increase the size of the bore.

The outer surface of the barrel is then turned in a lathe, the barrel being sustained by mandrels at each end. The tool may be fixed in a slide-rest which moves it longitudinally of the barrel, and also in or out to give the required taper from the breech to the muzzle, or the latter or transverse motion may be imparted to the tool-rest while the barrel has a longitudinal in addition to its rotary motion.

The barrel is then ground by being held parallel to and against the face of a rapidly revolving stone. For this purpose the barrel is slipped upon an iron rod and revolved by means of a crank on the end of the rod. The stones are cased in for safety, and also to keep the water from splashing upon the workmen, holes in the ends of the casing permitting the introduction and withdrawal of the barrel.

After grinding, the barrels are polished by hard-wood rubbers, supplied with lard-oil and emery. The barrels are placed in upright frames, several in each frame. The grooved ends of the rubbers are then pressed by springs against the barrels as they move up and down with a regular and rapid motion, the barrel, the while, revolving slowly. After remaining in the first polishing-machine for fifteen minutes or thereabouts, they are transferred to another and similar apparatus where the emery is dispensed with.

Much ingenuity has been expended in devices for detecting deflection or faults in gun-barrels, and for straightening them when unevenness is detected. The correction is made by placing the barrel on a small anvil and giving it a gentle blow with the hammer. The workman obtains artificial aid in detecting faults, by a transparent slate marked with two parallel lines and placed in a window. The barrel being pointed towards the window, the lines are reflected upon the polished interior surface of the barrel, and any unevenness throws the reflected lines out of parallelism; which is readily detected by the experienced workman. In former times, a hair or some other very slender line was passed through the barrel and drawn successively across each portion of the inner surface, concavities being revealed by the distance between the line and its reflected image in the metal.

For proving, the barrels are loaded with a heavy charge and then laid in a rank in the parallel grooves of a massive table in the proving-room, the charge in each piece being connected to a train of powder on the back of the stand, and passing to the outside of the building, so as to fire the charges from a place of security. The balls are received in a bank of earth, and those barrels which appear to have withstood the first charge are subjected to a second, smaller proving charge, to open any rent which may have been made by the former. Those which stand both tests are stamped with the mark of approval.

A still more severe test is filling the barrel with water, and driving in an air-tight bullet by heavy and repeated blows. If any chink or crack is to be found, the water will ooze from it.

The barrel having been welded, rolled, bored, turned, ground, polished, and proved, is now to be rifled by having twisting grooves cut in its interior. This is more fully referred to in this work under RIFLING-MACHINE, and is a very old device, specimens of rifled cannon and small-arms of the seventeenth century being preserved in European collections. In general features most of the machines agree; the barrel is firmly secured in the frame of the machine, and the grooves on its inner surface are cut by narrow bars of steel, which are placed within three apertures near the end of an iron tube which passes through the barrel by a slow compound motion, rotary and progressive.

The sight and cone seat are attached to the barrel at the proper stage of its progress, the former by brazing and the latter by welding.

Steel barrels are drawn from short bars, which are bored, heated, and drawn upon a mandrel between rolls, which successively lengthen and reduce the diameter of the barrel.

After boring and rifling, the grain or mottled appearance is produced by steeping in acids or by heating in boxes with charcoal, and then plunging in solution of ammonia. See BROWNING.

The principal imperfections to which gun-barrels are liable are the *chink*, the *crack*, and the *flaw*.

The *chink* is a small rent in the direction of the length of the barrel.

The *crack* is an imperfection across the barrel.

The *flaw* is a scale, or small plate, adhering to the barrel by a narrow base, from which it spreads out like the head of a nail from its shank, and when separated leaves a little pit in the metal which collects moisture and foulness, corroding the metal.

Gun-bar'rel Gage. The gage of large guns is the weight of the ball they carry, as 6-pounder, 8-pounder, 12-pounder, etc.

Or it is expressed in inches, and the fraction, if such there be, in decimals, as 8-inch, 10-inch.

The bore of the barrels of fire-arms is also denominated by the decimals of an inch, as .44, .45, .50, .55; all of which are somewhat common sizes.

The usual mode of denominating the barrels of sporting-rifles and fowling-pieces is by the number of bullets, of the diameter of the bore, that are contained in one pound of lead.

Gage-Table for Barrels of Fire-Arms.

No.	Diameter of Bore in 100ths of 1 Inch.	Weight of Leaden Bullet in Grains	No.	Diameter of Bore in 100ths of 1 Inch.	Weight of Leaden Bullet in Grains.
5	.98	1,400	19	.65+	$368\frac{8}{19}$
6	.93−	$1,666\frac{2}{3}$	20	.63+	355
7	.89	1,000	21	.63	$333\frac{1}{3}$
8	.85−	875	22	.62+	$318\frac{2}{11}$
9	.81−	$777\frac{7}{9}$	23	.61+	$304\frac{8}{23}$
10	.79	700	24	.61	$291\frac{2}{3}$
11	.77−	$636\frac{4}{11}$	25	.60+	280
12	.75+	$583\frac{1}{3}$	26	.59+	$269\frac{3}{13}$
13	.74−	$538\frac{10}{13}$	27	.59	$259\frac{7}{27}$
14	.72−	500	28	.58+	250
15	.70+	$466\frac{2}{3}$	29	.58−	$241\frac{11}{29}$
16	.69−	$437\frac{1}{2}$	30	.57	$233\frac{1}{3}$
17	.67+	$411\frac{13}{17}$	31	.56+	$225\frac{25}{31}$
18	.66	$388\frac{8}{9}$	32	.56−	$218\frac{3}{4}$

Gun-bat'ter-y. 1. (*Fortification.*) The emplacement of two or more pieces of artillery, destined to act on the offensive or defensive. It may be, —

Open; merely field-guns in position.

Covered; protected by a parapet.

Masked; disguised by a screen of branches, or other obstructions to the view.

Enfilading; sweeping the face of the body of troops or the works, by a fire in the line of the length of the object.

En echarpe; having a line of fire oblique with the face of the object.

En revers; playing upon the rear of the enemy.

Cross-fire; several batteries having a converging fire upon an object.

Siege ; of a large description, for breaching.

a. Elevated ; on the natural level of the ground.

b. Half-sunken ; when the *parapet* is partly made of earth from the *terre-plein* or gun-platform.

c. Full-sunken ; when the *terre-plein* is farther lowered by taking all the earth therefrom to form the *parapet.*

Casemate ; when protected by a bomb-proof chamber and firing from *embrasures.*

Barbette ; firing over a parapet.

Breaching ; devoted to making an opening in the wall of a fortification.

Ricochet ; when the balls, with a low charge, traverse the inner face of the enemy's works and rebound and roll along the same.

Mountain ; light pieces adapted to be dismounted, and, with their dislocated carriages, carried on mules.

2. (*Field-artillery.*) The tactical unit of field-artillery. A certain number of field-guns under one command, together with the officers, men, horses, wagons, and stores.

An English field-battery has six 12-pounder, Armstrong, breech-loading, rifled guns. Each gun has its limber, and the battery has 22 other carriages and 210 horses. It is officered and manned by two captains, three lieutenants, and 236 non-commissioned officers and men.

Three field-guns to 1,000 men is the usual proportion in European armies.

Gun'boat. A small vessel of war, carrying from one to four guns if sea-going. Gunboats in the United States Service are usually fourth-rates. See IRON-CLAD.

The gunboats employed for river service by the United States government during the late civil war were generally flat-bottomed, side-wheeled craft, of light draft, and partially iron-plated above the water-line with from two to four inches of iron, backed by eighteen to thirty inches of oak, set at an incline of 55° or thereabouts. The strongest plating was forward, and when these vessels could fight "bow on" they were considered invulnerable to 64-pound shot. They carried from four to sixteen guns, which were fired through portholes. (See illustration on opposite page.)

Auxiliary to the gunboats was a fleet of steam-rams, built especially for speed, and calculated to run down and sink an enemy. They generally carried one gun.

Gun-car'riage. The apparatus upon which a cannon is mounted for service. It may or may not be adapted for the transportation of the piece.

The first consisted merely of a timber-block, or frame, to which the cannon was secured by straps or bolts. Uprights, with holes for pegs, were sometimes employed to give elevation to the muzzle. Afterwards a species of trough, having a butt-piece and mounted on wheels, was introduced (*A*, Fig. 2339). Subsequent improvements brought them nearly to the form *B*, which represents a carriage of the Gribeauval pattern. Gribeauval, a French artillery officer, made great improvements, 1765, in gun-carriages and the organization of artillery, reducing the size of the parts, and making the similar parts, for those of the same class, interchangeable; he also added a tongue, so that two horses could draw abreast, and made the limbers so that one sort would answer for several different kinds of carriages.

Land gun-carriages comprise field, siege, casemate, and barbette carriages. The two former are adapted for the transportation as well as service of the piece, while the latter are intended to be kept in one position in a fortification. A smaller kind of field-carriage may be readily taken to pieces and put together, so as to be carried on mules' backs in a rugged and mountainous country.

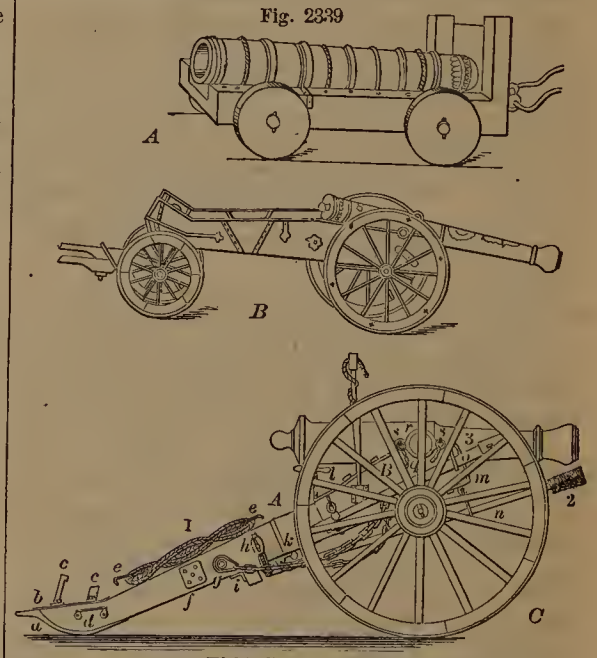
Field-carriages include those which are adapted to accompany the movements of troops during an engagement, and carrying a class of guns weighing from 800 to 1200 pounds, as the 12-pounder smooth-bore and lighter rifled cannon.

These carriages are known as "stocktrail" pattern, from having a single piece, which serves as the trail, inserted between the two cheeks on which the trunnions rest.

The Gribeauval and older patterns of carriage had no stock, the ends of the cheeks resting immediately on the ground; the fore-wheels were also smaller than the hinder.

C is an elevation of a field-gun carriage without its limber. The various parts are, —

Fig. 2339



Field-Gun Carriage.

A, stock.
B, cheek.
a, lunette.
b, trail-plate.
c c, pointing rings.
d, handle.
e e, prolonge hooks.
f, wheel-guard plate.
g, lock chain, bolt, nut, and washer.
h, turn-buckle, chain, and hasp for sponge and rammer.
i, stop for rammer-head.
k, ear-plate for worm.
l, elevating-screw.
m, under-strap.
n, implement-hook.
o, D-ring for hand-spike.
q, trunnion-plate.
r, cap-square.
s, cap-square chains and keys.
1, prolonge.
2, sponge and rammer.
3, hand-spike.

The detachable forepart of the carriage is called the limber. It carries a chest for containing ammunition, upon which the cannoniers sit. The limbers for all field-carriages differ only in the interior fitting up of the chest, adapting it for receiving different kinds of ammunition.

A *caisson* for carrying ammunition accompanies each field-piece. This vehicle has a limber similar to that of the gun-carriage. Its rear part, or body, carries two ammunition-chests, the three, with that on the carriage-limber, containing the full supply of ammunition for the piece.

Each field-battery of four or more pieces is also accompanied by a *traveling-forge* and a *battery-wagon,*

GUNBOAT FLOTILLA ON THE MISSISSIPPI RIVER.

PLATE XXIII.

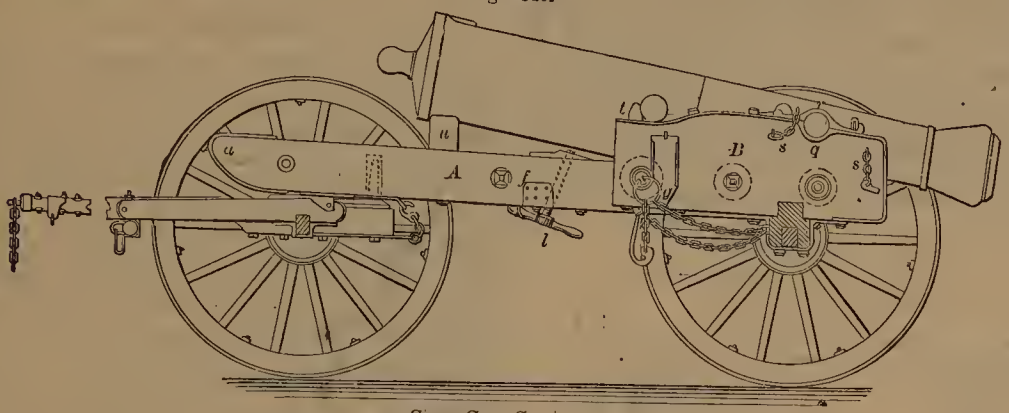
See page 1034.

which contain the necessary tools and materials for ordinary repairs.

Each carriage is drawn by six horses, harnessed in a manner somewhat different from the ordinary way, the traces of the wheel horses being directly attached to the splinter-bar of the limber, and the traces of the leaders connected to those of the wheel-horses. Swingletrees and whiffletrees are thus dispensed with.

The siege-carriage (Fig. 2340), though larger and heavier than that for field service, differs little from it in general construction. For transportation the gun is moved backward, the trunnions resting against the head of the traveling trunnion-bolt *t*,

Fig 2340.



Siege-Gun Carriage.

the breech supported on the bolster *u*. The small parts for holding the implements are wanting.

Three sizes are employed in the United States artillery service, one for the 4½-inch rifled gun, one for the 18-pounder smooth bore and 30-pounder rifled gun, and one for the 24-pounder and 8-inch howitzer.

Barbette carriages are intended for firing over the parapet of a fortification, and are adapted to mount guns of 32-pounder, 8-inch, 10-inch, 15-inch, and 20-inch caliber. The carriage proper rests on a frame called the *chassis*, which turns about a fixed pintle, so that it may be traversed to point wholly or partially around the circle. See BARBETTE.

Casemate carriages resemble the above in their general construction, but are somewhat less high in proportion. They are placed in casemates, where the gun is fired through an embrasure. See CASEMATE.

These two latter classes of carriages, and also mortar beds, have since 1860 been made of wrought-iron, which material has also been tried to some extent for field-carriages with a promise of good results. Cast-iron was at one time tried and found utterly unsuitable.

Ordinary broadside naval gun-carriages much resemble the army casemate carriage, but have no chassis. They are mounted upon four small wheels, called "trucks," and are run in and out and pointed by means of two *side tackles*, hooked respectively on the left and right to the side of the ship, and a *train-tackle* hooked to a ring-bolt behind the carriage. Excessive recoil is checked by the breeching, a stout rope passing through a hole in the cascabel of the gun, and shackled to the ship's ribs on either side. Elevation is given either by means of a graduated quoin or an elevating screw.

In the *Marsilly* carriage the two front rollers are wanting, the front transom resting immediately on the deck.

Light broadside guns and boat guns have their carriages arranged to run on slides corresponding to a chassis, and have compressors for moderating the recoil. Boat guns are also provided with field-carriages of iron in order that they may be employed on shore.

Heavy pivot guns as 11-inch, on upper decks, are mounted on a peculiar carriage, which enables them to be directed to any point around the circle by means of side tackles and *in* and *out* tackles hooked to bolts appropriately placed around the deck.

Very heavy guns, as 15-inch or 20-inch, being always placed in revolving turrets, their carriages need have no lateral motion, as this is obtained by the rotation of the turret itself, operated by connection with the engine of the ship. Devices similarly operated are also provided for loading. See BATTERY-FORGE, BATTERY-WAGON, CAISSON, BARBETTE-CARRIAGE, CASEMATE-CARRIAGE, MORTAR.

The necessities of modern warfare, land and marine, have given rise to many inventions for operating heavy guns and for the protection of those working them. For the latter purpose, besides mantelets and shields, arrangements have been made for rotating the turret in which the gun is mounted so as to cover the embrasure; depressing the gun during loading below the embrasure, etc.

For counterpoise carriages see: —

Brewer's gun-carriage, 1870, is supported on a platform which is supported by levers within a curb, and a weight suspended from the ends of the levers counterpoises the gun, carriage, chassis, and platform.

Callender and Northrup, 1864, have a platform supported by a piston in an air-cylinder beneath.

Eads (1865, 1869, and 1871) causes the recoil of the gun to depress it backwardly and downwardly, it being poised on its trunnions on the end of an arm which oscillates in an arc. As the gun descends, a piston traverses in a cylinder, compressing air therein, and the elasticity of the air assists in restoring the gun to its position when the loading is complete.

Coughlan, 1870, has a cogged segment and weighted toggle which allow the gun to depress by the force of recoil.

Taggart, 1863, has two guns on a cylindrical carriage which is on an axis reaching athwart the vessel. The gun beneath is in loading position below decks, while the one above is in firing position. The latter being fired, the axis is rotated and the guns change places.

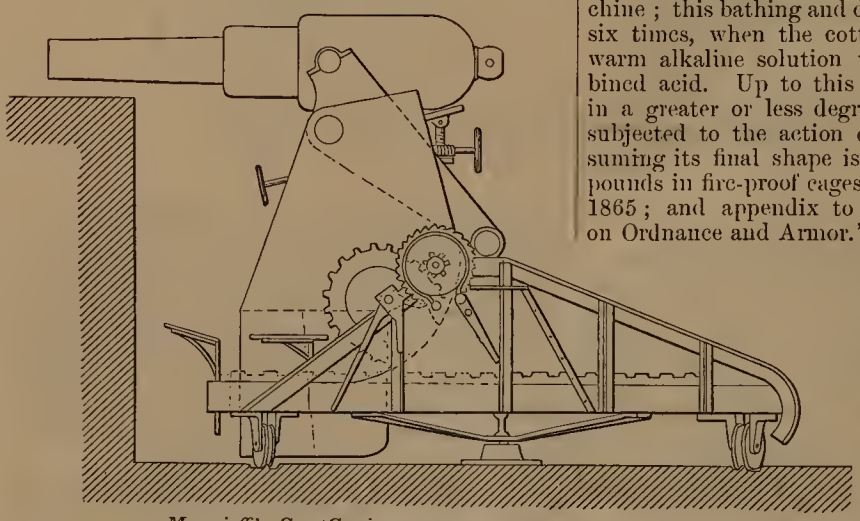
Winans, 1865, lifts his gun, carriage, and traverse into firing position by steam piston and cylinder beneath.

Houel and Caillet have a system of levers which oscillate backwardly by the recoil, and in so doing bring into action a spring which afterward assists in restoring the gun to firing position. See also Coon, 1863; Foster, 1869.

Wappich, 1863, has a toggle-joint and screw for elevation and depression. Also screws beneath the trunnions.

In Moncrieff's gun-carriage (Fig. 2341) the gun is supported upon a moving fulcrum, which, on the firing of the gun, is caused to shift nearer to the gun and farther from a counterweight, spring, or other force, while at the same time the gun is brought into a lowered position for reloading, and is then automatically raised into position for firing. By the shifting of the fulcrum, the statical momentum of the balance weight is made to preponderate so greatly over that of the gun that it will, when allowed free action, after the loading of the gun, raise the same into its original position.

Fig. 2341



Moncrieff's Gun-Carriage.

For running the gun in and out of battery, and traversing and operating guns in turrets, see patent of Ericsson, 1866, 1870; Perley, 1865, 1867; Eads, 1864, 1865; Bartol, 1863. Training twin guns in parallelism in turrets, Eads, 1866.

Eads, 1864, 1865, has a means for training the gun upon an imaginary center, which is the center of the exterior opening of the port or embrasure, so as to reduce the opening to the smallest size.

Gun-cot'ton. The first notice of the discovery of gun-cotton was made by Braconnet, in 1833, who detailed the action of nitric acid on starch, sawdust, linen, and cotton. He called it *xyloidine*.

Pelouse, in 1838, called attention to this compound.

Dumas, in 1843, again cited a mode of preparing, and made suggestions for the application.

Schönbein, in 1846, brought forward his plan of using nitric and sulphuric acids. It was described by W. H. Ellet of Columbia, S. C., in 1846.

Baron Von Lenk, 1864, used cotton skeins instead of employing the wool in masses, thus rendering the saturation more complete and the manipulation easier. The loose cotton thread is first boiled in an alkaline solution and afterwards placed in a cylinder with perforated wire sides, making from 600 to 800 revolutions per minute, by which the alkali is expressed; it is then washed in clean water and again subjected to the action of the cylinder, after which it is thoroughly dried by exposure to air and by heating in a chamber to about 120°.

One-pound charges of the cotton thus prepared are next immersed in a mixture composed of 3 parts of sulphuric to 1 of nitric acid, which has been allowed to cool from 48 to 72 hours; the vessels containing the cotton and acid being surrounded with cold water to prevent undue heating during the chemical action which ensues.

The cotton is then placed on a strainer and expressed until it retains but about ten times its weight of acids, when it is removed to an earthenware jar, surrounded by water as before, where it is allowed to remain forty-eight hours to insure its complete conversion into "trinitro cellulose," or gun-cotton. It is then taken out and washed by plunging suddenly in water, to prevent heating; and afterwards placed in a tank of running water for forty-eight hours, and dried in the centrifugal machine; this bathing and draining process is repeated six times, when the cotton is finally washed in a warm alkaline solution to remove all the uncombined acid. Up to this period the cotton has been in a greater or less degree damp, since it was first subjected to the action of the acids, but after assuming its final shape is dried in charges of twenty pounds in fire-proof cages. See also Revy's process, 1865; and appendix to A. L. Holley's "Treatise on Ordnance and Armor."

Mr. Abel, of the Woolwich (England) Dock-Yard Chemical Department, has discovered that the explosive force of gun-cotton, like that of nitro-glycerine, may be developed by the exposure of the substance to the sudden concussion produced by a detonation, and that if exploded by that agency the suddenness and consequent violence of its action greatly exceeds that of its explosion by means of a highly heated body of flame.

Charges for sporting or blasting purposes are sometimes put up with a core of raw cotton, to diminish the force of explosion.

Wet gun-cotton is of course proof against explosion by heat, but it has been found that its explosive energy is rather increased than diminished when wet and fired by percussion. A body of gun-cotton thrown into the sea in a net, with a protected priming of dry cotton and fulminate, will explode with as much force as if confined in a water-tight vessel.

The rapidity with which gun-cotton detonates has been computed at 20,000 feet per second. Its energy is from two to four times that of gunpowder. See EXPLOSIVES.

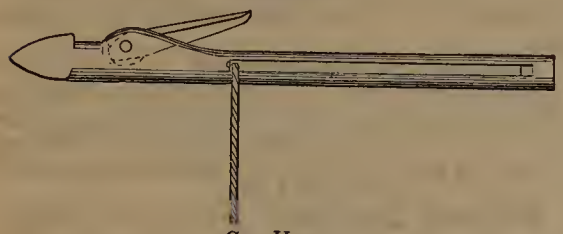
Gun-cotton is not soluble in alcohol or ether, but in a mixture of the two it dissolves readily, giving rise to a perfectly colorless mucilaginous liquid, known as *collodion*. This dries quickly to a hard skin, quite structureless, and possessing considerable strength. It is used in surgery, and also, in conjunction with iodides and bromides, to form the collodion of the photographer. See PYROXYLINE.

Gun-deck. The lower deck of a ship of war.

Gun-har-poon'. One fired from a gun, used mounted in a crutch on the gunwale of a whaleboat. It is made of steel, and has a chain or long-shackle attached to it, to which the whale-line is fastened. Some gun-harpoons carry a grenade or flask of poison which breaks and sickens the whale.

In the illustration, the harpoon has a hinged barb

Fig. 2342.



Gun-Harpoon.

and a slotted shank, in which is a sliding link to which the line is fastened. The rear end of the slot has an elastic guard to receive the shock of the ring as the harpoon is fired. See HARPOON.

Gun-lock. The combination of parts by which the propulsive charge is caused to ignite. The matchlock, the first known employment of which was at the battle of Morat, 1476, was the earliest known form. In this a piece of slow-burning cord was passed through a hole in the cock, which was thrown forward on pulling the trigger, bringing the lighted end of the cord in contact with the priming. The gun with this attachment was called an arquebus. It continued in use until the invention of the wheel-lock in Italy, about 1521. In this, a furrowed steel wheel was, by means of a spring and chain, caused to revolve in contact with a piece of native sulphuret of iron, producing sparks which ignited the priming. This mineral is said to have originally derived its name pyrites, or firestone, from having been thus employed.

The "snaphaunce" lock comprised a hammer carrying a flint, which was caused to strike against a furrowed piece of steel, which performed the office of the battery in the more modern flint-lock. It is said to have been contrived by German or Dutch marauders, to avoid the exposure attending the use of the matchlock in nocturnal expeditions.

The flint-lock is said to have originated in France about 1635, and its general features do not appear to have essentially changed in the two centuries, nearly, during which it was used to the exclusion of all others. The parts corresponded to those of the percussion-lock of the present day, except that the hammer was provided with a pair of jaws for holding the flint, which was caused to strike a pivoted lip called the *battery*, throwing it back and dropping a shower of sparks into the "pan" containing the priming.

In 1807 Rev. Mr. Forsyth obtained a patent in England for a fulminating powder, which was to be placed in a magazine at the breech of the gun and fired by a pin. Various modifications were devised prior to the introduction of the common copper cap, about 1816. This, however, made its way rather slowly. It was not until 1842 that the percussion lock and cap were adopted in the United States military service.

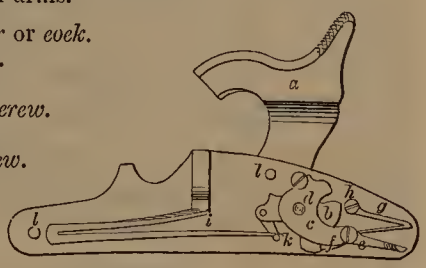
The adaptation of the flint-lock to cannon was easy, it being merely necessary to secure the lock in position by a ring around the breech of the gun; when the hammer fell back, on firing, the blast from the vent passed freely, without injury to the lock. It was otherwise with percussion-locks when applied to a vent two tenths of an inch in diameter. The shock of the blast would soon have destroyed such a lock without the hammer was withdrawn from over the vent at the very instant of firing. This difficulty was obviated by E. Hidden's lock, first patented in 1831 and subsequently improved.

In this, that end of the hammer to which the lanyard is attached is longitudinally slotted, so that the same pull which brings the hammer down upon the head of the primer withdraws it back a slight distance, leaving the blast unimpeded. Friction primers for cannon have generally superseded the use of this lock, though it still maintains its place in the United States navy.

The elements of all gun-locks of the modern pattern, which have no breech-loading or revolving machinery to operate, are essentially as follows. The illustration shows that employed in the United States muzzle-loading small-arms.

Fig. 2343.

a, hammer or *cock.*
b, tumbler.
c, bridle.
d, bridle-screw.
e, sear.
f, sear-screw.



Gun-Lock.

g, sear-spring.
h, sear-spring screw.
i, mainspring.
k, swivel.
l l, side screws.

The hammer fits on the *square* of the *tumbler*, which it rotates when drawn back, so as to allow the *nose* of the sear to fall into notches of the tumbler when at half-cock and at cock. Both the sear and tumbler are held in place by the *bridle*, which confines them to the lock-plate. The trigger, when pressed, acts on the rear end of the sear, lifting the other end out of the cock-notch of the tumbler, which is then permitted to move by the action of the mainspring, carrying the hammer around with it.

Revolving, breech-loading, and repeating arms, having their firing mechanism necessarily operating in connection with those for loading and for withdrawing the cartridge-cases, require very different arrangements from those described, in many instances involving great multiplicity and complexity of parts. These will be found noticed under the head of FIRE-ARM, where a list of about 1000 occurs.

The lock of the needle-gun is the widest departure from the well-remembered form, the striker being a pointed rod which explodes the fulminate, either in the base of the ball, as in the Prussian gun, or in the base of the capsule, as in the American form of rifles. The percussion powder may be in a cap placed on a nipple on the side of the barrel; in a cap over a nipple on the cartridge; a pellet on an anvil at the base of the cartridge; a pellet or ring in a basin or in the flange of the cartridge; a pellet in the base of the bullet.

By position it may be *rear*-fire, *front*-fire, *side*-fire, *center*-fire. See CARTRIDGE; FIRE-ARM.

Gun-lock Ham'mer. The cock or striker of a fire-arm lock. See GUN-LOCK.

Gun-met'al. A bronze from which cannon may be cast. Ordinarily 9 parts copper and 1 tin. Other metals have been sometimes added or substituted for the tin, copper still remaining the basis of the alloy.

A few examples are given.

	Copper.	Tin.	Zinc.	Iron.
Common formula . .	9	1		
Stirling's (English) .	50		25	1–8
Rosthorn's (Austrian) .	55.04	0.83	42.36	1.77
Rosthorn's (Austrian)	57.63	0.15	40.22	1.86
Navy (Austrian) . .	60		38.12	1.8
Birkholtz (U. States)	60		38	2.0

	Copper.	Aluminum.	Zinc.	Iron.
Keirs (English, 1799)	100		75	10
Lancaster's (English)	90	10		

See ALLOY.

The Rosthorn (Austrian) alloys are known as "sterro-metal." One variety is soft, ductile, and capable of being worked into sheets or wire. The other is hard, and is represented as suitable for ordnance. From experiments made at the Imperial arsenal at Vienna, its tensile strength was, after single fusion, 28 tons to the square inch; after forging at a red heat, 32 tons; drawn cold and reduced from 100 to 77 sectional area, 37 tons. The metal thus tested contained a rather less proportion of tin and iron than is indicated above. Its specific gravity was 8.37. It is represented as possessing unusual elasticity. Field-guns of from 4 to 12 pounder caliber were worked out of single pieces under the hydraulic press, without impairing its tensile strength.

M. Sorel's alloy, composed of 8 copper, 1 zinc, and 1 tin, is said to resemble zinc in appearance, to be equal to copper and iron in hardness, more tenacious than soft cast-iron, readily turned, filed, and delivered from the mold in casting, and to endure exposure to moisture without tarnishing. It is susceptible of being bronzed, and is adapted for statues or exposed ornamental objects.

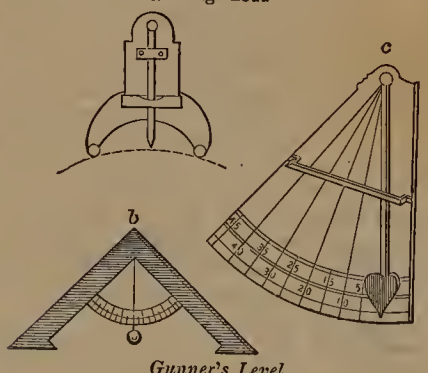
Gun'ner's Cal'i-pers. An instrument made of sheet-brass with steel points. The graduations show the diameters of shot and shell, the calibers of guns, linear inches, degrees of the circle, etc.

Gun'ner's Hav'er-sack. A leathern bag worn by a gunner for containing the smaller implements required in the discharge of his duty.

Gun'ner's Lev'el. An instrument for ascertaining the highest points at the breech and muzzle of a piece of ordnance, when on uneven ground, in order to determine the true line of sight.

It consists (*a*, Fig. 2344) of a spirit-level mounted on a frame having two branches with rounded ends,

Fig. 2344



Gunner's Level.

and an upright piece with a perpendicular slider. The instrument is placed transversely on the upper part of the gun, say at the base ring, and moved to the right or left until the bubble of the level is central, the point of the slider then indicates the highest point of the piece at that part; repeating the operation at the muzzle gives another point in the line of sight, along which the gunner must aim to hit the object. These points are then marked on the metal.

Called also gunner's perpendicular.

b and *c* represent forms of what are called gunner's levels in the British service. Each of these is designed to be applied longitudinally to the gun to give it the proper elevation, the degree of which is ascertained by the graduated quadrant and plumb-bob.

Gun'ner's Per'pen-dic'u-lar. Another name of the gunner's level. It is made of sheet-brass, the lower part being cut out in crescent shape. It has a perpendicular slider, pointed at the lower end, and is used for finding the line of sight of siege-guns and mortars. See GUNNER'S LEVEL.

Gun'ner's Quad'rant. The gunner's quadrant is a graduated arc of 90°, or rather more, made of brass or wood, and having an arm attached which is passed into the bore of the gun for the purpose of ascertaining the elevation. The wooden level has a leaden bullet suspended by a string, which indicates the perpendicular, the deviation from which is measured on the arc. The metallic quadrant is of more elaborate construction, and has a spirit-level attached. See GUNNER'S LEVEL.

Gun'nie. (*Mining.*) *a.* A large, open, excavated space in a mine.

b. In Cornish, a term applied to breadth or width; *single* gunnies are three feet wide.

Gun'ny. (*Fabric.*) A heavy coarse goods used for wrapping bales of cotton, for cotton bags, etc. Made of jute, manilla, or hemp. A heavier grade than *burlaps*. Gunny is a Hindoo word, and the real article is made from fibers of the *cochorus* (jute); the bag made thereof is used to carry grain, etc., on the backs of buffaloes, and for enclosing articles for exportation, — rice, saltpeter, pepper, coffee.

Gun-pend'u-lum. 1. A pendulous box with sand-bags to receive the impact of a ball fired from a gun or cannon, and used to determine the strength of powder. See BALLISTIC PENDULUM.

2. A gun suspended from trunnions to measure by recoil the power of the powder of the exploded charge. See also ÉPROUVETTE.

A substitute means is a measurer of the rate of motion of the projectile, which forms one factor in the calculation for the power of the powder. See CHRONOSCOPE.

Gun'pow-der. A composition of niter, charcoal, and sulphur. The proportions in which these ingredients are mixed vary slightly, according to the place of manufacture or the destined use of the article. By the atomic theory there should be in 100 parts, 74.64 niter, 13.51 charcoal, 11.85 sulphur. In practice there are employed, —

	Niter.	Charcoal.	Sulphur.
In the United States, military purposes	76	14	10
Or	75	15	10
In the United States, sporting	78	12	10
	77	13	10
In England, military purposes	75	15	10
In England, sporting	78	14	8
	75	17	8
In France, military purposes	75	12.5	12.5
In France, sporting	78	12	10
In France, blasting	62	18	20
In Prussia, military purposes	75	13.5	11.5

Although the use of gunpowder in Europe can be traced back only to the middle or earlier part of the fourteenth century, yet it seems fully proved from various passages in ancient authors that it is one of those inventions whose origin is lost in the obscurity of a very remote antiquity. The fact appears indisputable that it originated in Central or Eastern Asia, where it was used for many ages previous to its introduction into Europe, where it appears to have been first made known by the Saracens.

In a code of Gentoo laws occurs a prohibition against the use by the ruler of "deceitful machines, poisoned weapons, and weapons of fire." To this document is assigned the date 1500 B. C. When Ghengis Khan invaded China, A. D. 1219, he carried with him *ho-puo*, or fire-tubes, which killed men and set fire to buildings.

Passages in Quintius Curtius and Philostratus indicate that Alexander was met in India by a people who used against him "storms of lightning and thunderbolts."

There are many scattered passages in the old writers, and many facts, quoted by Dutens, Sir George Staunton, Halhed, Hallam, M. Langles, Muratori, Reinaud, and Grove, which indicate the very early use of gunpowder.

It must be recollected that in many parts of Asia saltpeter occurs as an efflorescence on the surface of the ground, and its sputtering effects upon ignited charcoal, when a fire was built upon it, must have been very commonly observed. Sulphur is useful in the combination, but not essential for some purposes to which the explosive compound is applied.

In early ages, probably as early as the time of the exodus of the Israelites from Egypt, fire-works were common in China, and from thence, at a very remote period, they spread to India, where they were used on a scale which made them dangerous weapons when Alexander invaded that country, 327 B. C. There is no reasonable doubt that, long before they were employed as weapons, rockets and other pyrotechnic devices were used among these Eastern Asiatic nations, especially among the Chinese, with whom they have for many centuries formed an important item in public celebrations and festivals. From those devices, in which a charged paper tube expels fire-balls or pellets of explosive material, the transition is very easy to larger tubes with projectiles, which depend for execution upon percussive force. Such were the original fire-arms, and the strengthened paper tube or the bamboo was the first barrel.

We have occasion to notice, in the course of this work, that many arts in which the Chinese excelled were carried to India, and were cultivated in that congenial soil, until an irruption of another nation scattered the artificers or scholars, and gave to the world the secret or the industry which was locked up, as it were, within circumscribed limits. This has commonly occurred in the history of the industrial arts.

War quickened the extension of printing. In 1482 the storming of Mentz dispersed the workmen, and gave the art of printing to the world.

In 1146 Roger of Sicily plundered Greece, and took home with him to Palermo silk-worms, workmen, and the art of weaving silk. From Sicily it spread to France, Italy, and Spain, and from Italy to England.

Other instances might be cited where the irruptions of tribes or nations, or internecine disturbances, have disseminated arts, but the one most to our purpose is the invasion of India by Mahmoud of Ghizni, A. D. 1004, which seems to have been the means of diffusing the knowledge of gunpowder, the mariner's compass, and the art of glazing pottery and earthenware. The Saracens were the means of publishing the knowledge thus dispersed, and we regard it as certain that they introduced the knowledge of gunpowder into Europe.

The art of making felted fabrics was reintroduced into Europe by the Tartar hordes who took Thrace and Adrianople in 1361, and under Bajazet overran the provinces of the Eastern Empire before the end of that century.

The arts of making silk and other fine goods, crystal glasses, and jewelry, were carried to the Netherlands and to England by the Revocation of the Edict of Nantes, granted by Henry IV. in 1598, confirmed by Louis XI. in 1610, and Louis XIV. in 1652, and revoked by Louis XIV., Oct. 22, 1685. Fifty thousand Protestant families left France for more tolerant countries, and the world is the better off from the diffusion of their skill.

The more closely we examine the record, the more do we discover our indebtedness to the East; and the extreme East seems to have been the primary fountain of our industrial civilization.

The use of an explosive compound, *pulvis nitratus*, is mentioned in an Arabic writing in the Escurial collection, dating about 1249. The Moors used it in Spain in 1312, and in 1331 the king of Granada battered Alicant with iron bullets, discharged by fire from machines. In 1342–43, the Moorish garrison of Algesiras defended themselves against Alonzo XI., king of Castile, by projectiles fired from cannon by powder.

The Venetians used gunpowder in their wars with the Genoese in 1380. Gunpowder is mentioned in the French national accounts, 1338, and is said to have been used at Cressy, 1346, and to have contributed much to the success of the English.

The two Europeans whose names have been prominently brought forward as inventors of gunpowder are Roger Bacon and Michael Schwartz.

Roger Bacon, in 1216, wrote a work entitled "The Secrets of Art and Nature," wherein he states that "from saltpeter and other ingredients we are able to make a fire that shall burn at what distance we please; and that sounds and coruscations resembling thunder and lightning might be formed in the air, much more to be dreaded than those that happen naturally, inasmuch as by its power armies and cities might be destroyed.' Bacon did not claim the discovery, and had probably read the "Liber Ignium" of Marcus Græcus, written about A. D. 825, in which he describes the nature of the composition for making rockets. His formula is stated by one authority to have been, — sulphur, 1; charcoal, 2; saltpeter, 6. It is now difficult to sift the error from the truth, but it is said that in the recipe of Bacon the ingredients saltpeter and sulphur were given, and that the charcoal was stated anagrammatically, by the transposition of the letters of the words, *carbonum pulvere;* which he wrote "Lura nope cum ubre." This looks as though he considered it a secret; not necessarily his invention, but a dangerous compound not adapted for the use of the vulgar.

Michael Schwartz, a Cordelier monk, of Goslar, in Germany, about A. D. 1320, seems to have combined the three ingredients, and has been credited with the discovery. A commemorative statue of Schwartz was erected in 1853, at Freiburg.

Artillery was known in France in 1345.

In 1356, the city of Nuremberg purchased gunpowder and cannon.

The same year Louvain employed thirty cannon at the battle of Santfliet against the Flemings.

In 1361, a fire broke out at Lubec from the careless use of gunpowder.

In 1363, the Hanse towns used gunpowder in a conflict with the Danes.

It is commonly stated that gunpowder was first made in England, at periods varying from 1411 to 1438; but recent research by Rev. Joseph Hunter has brought to light records of its manufacture for the uses of the English army before it landed at La Hague, and previous to the battle of Cressy.

The ingredients for the manufacture of gunpowder should be of the greatest possible purity. The crude saltpeter is refined by washing, and then dissolving in the least possible proportion of hot water, and clarified by adding a very small quantity of glue, and boiling until the impurities, such as chloride of sodium, are deposited and the liquid becomes perfectly clear. It is then drawn off into pans, where it is cooled and crystallized in very minute grains, and afterwards washed with cold water, dried, and sieved. It should not contain more than $\frac{1}{3000}$ part of chlorides. That used in the best powder does not contain more than $\frac{1}{1500}$, and for the best sporting powder it undergoes a second refining, and contains not more than $\frac{1}{6000}$ part.

The charcoal has a great effect upon the quality of the powder. It should be light, friable, and porous, burning freely, and leaving little ashes. The woods used are willow and black-alder, principally the former. Branches not exceeding $\frac{3}{4}$ inch diameter are selected, barked, and dried, after which they are charred in upright cast-iron cylinders, heated from the outside; about 65 per cent of the weight is found to pass off in the gaseous products distilled from the wood, leaving only 35 per cent of coal. It should only be prepared as required for use, owing to its liability to absorb moisture, and to spontaneous combustion when stored in quantities exceeding 30 pounds' weight.

Sulphur is refined by sublimation, the chamber in which the vapors condense being kept at a temperature of about 248° F., so as to allow the sulphur to be drawn off in liquid form. If much lower than this it condenses in the form of a powder, called flowers of sulphur, which always contains a proportion of sulphurous and sulphuric acids.

The three ingredients are now incorporated.

Dr. Scoffern's description of the process as conducted at the National Mills at Waltham, England, which produce powder of unsurpassed quality, gives a good general idea of the mode of manufacture.

It may be remarked that the process commonly employed in this country, though almost identical, differs somewhat in the preliminaries. Here the saltpeter is usually found sufficiently pulverized as it comes from the refinery. The charcoal is pulverized by being placed in a large cast-iron barrel, having ledges on its interior, with twice its weight of bronze balls, and the barrel is caused to rotate at the rate of from 20 to 25 revolutions per minute for two or three hours. The sulphur is similarly treated in barrels made of thick leather stretched over a wooden frame, and revolved from four to eight hours. The ingredients are incorporated by placing the charcoal and sulphur together in a rolling barrel, similar to that in which the sulphur is pulverized, and rolling them for one hour. The saltpeter is then added and rolled for three hours longer, after which the mixture is transferred to the cylinder or rolling mill, which consists of two cast-iron cylinders rolling in a circular trough with a cast-iron bottom.

At Waltham, the saltpeter, brimstone, and charcoal are ground separately in mills, each consisting of a pair of heavy circular stones slowly revolving on a stone bed. Next the ingredients are conveyed to the *mixing-house*. Here, in bins, are the saltpeter, brimstone, and charcoal, weighed in the exact proportions: saltpeter, 75; brimstone, 10; and charcoal, 15; in every 100 parts. Of the three ingredients, forty-two pounds are placed in a hollow drum, which revolves rapidly, and contains a fly-pan, which rotates in an opposite direction; in about five minutes a complete mixture is effected, and the charge is received in a bag tied over the lower orifice of the drum.

The *composition* is next taken to the *incorporating-mills*, and is now a *combustible* compound, which will acquire an *explosive* power by the thorough incorporation of ingredients. The mill consists of a pair of circular stones (*runners*) weighing about 3½ tons each, and slowly rolling over the powder, which is placed on the stone bed of the mill, surrounded by a huge wooden basin. The powder is previously damped, as it could not be safely ground dry; about seven pints of water (*liquor*) being added to the charge of forty-two pounds of powder during three and a half hours, the time of grinding. To insure this with precision, and to obviate the chance of any irregularity in a clock, the water-wheel which works two of these mills in one house also marks its revolutions on a dial, so that the attendant can never be mistaken in the time the charge has been "on," — a most important point, where the over-grinding of the too dry powder might cause it to explode. Sometimes a portion of the wood-work of the roof, or mill, becoming detached — such as a cog of the wheel — and falling into the pan, acts to cause a mass of powder to explode. As a protection, over each house containing a pair of mills is suspended a flat board, which, in case of an explosion, is first blown upward, and, being connected by wires to a cistern of water over the pan of the fellow mill, upsets the same, and drowns the gunpowder. The attendants are as little as possible in these mills, and only work by daylight. More hazardous processes, however, follow. The powder thus incorporated is in hard, flat lumps, and has again to be reduced to dust in the *breaking-down house*, by conveying it down an inclined plane, through rollers, which crush nearly 500 pounds in the hour. The powder is then taken to the *press-house*, and there, between gun-metal plates, is pressed in thin cakes to one third its bulk by a power of 700 tons in an hydraulic press. The cakes are roughly broken up, and sent in baskets to the *granulating-mill*, where the powder is again broken down into grains, the size being regulated by sieves. The floor is covered with hides fastened down with copper nails, and the mill can be started or stopped by a rope passing through the wall, which is bomb-proof. The powder is then dried, by heat, in the *stoving-room*, which is flanked externally by *traverses* (mounds of earth thirty feet thick), to confine explosion, should it happen, as much as possible to one house. Lastly, the powder is sifted in the *dusting-house*, where the sieves revolve with great velocity; the dust escapes through the meshes, and the gunpowder is drawn off through a sort of tap, into barrels, for packing. The finest powder is *glazed* by black-lead being shaken up with it; but cannon powder has not this finish.

The size of grain of gunpowder is varied according to its intended use. The finest is known as *sporting*, the next *rifle*, then *musket*, and lastly *cannon* powder. The rapidity of burning is in inverse proportion to the size of the grain. For very heavy ordnance a much larger grained powder than either of the above, called *mammoth* powder, was introduced by the late General T. J. Rodman. He also proposed the use of a powder composed of small uniform cakes with cylindrical perforations. This has since, under the name of *prismatic* powder by the Germans and Russians, and *pebble* powder by the English, been received with considerable favor.

The use of sawdust, resin, bran, sand, ashes, wood shavings, is as old as the writings of Siemienowicz,

1651. He remarked, very truly, that they have the effect of making the powder burn more slowly. The practice has been again and again introduced, in Brazil about 1800; by Thurnagel in Germany; Thomassin and Leblanc in France; Firzoo in Russia.

Dr. Gale has shown that by the addition of sand in certain proportions the powder is rendered non-explosive.

The white gunpowder invented by Captain Schultze, of the Prussian army, is prepared by sawing suitable kinds of wood into thin slices transversely of the grain. These are then, by means of a manifold punch, cut into grains of a definite size and shape, which are chemically washed to remove calcareous and other non-woody matters, and then treated with a mixture of nitric and sulphuric acids, washed with a solution of carbonate of soda and dried. In this condition the powder is stored away until it is wanted for shipment. It may be considered as a dense form of pyroxyline. The explosive quality is imparted by steeping in a solution of some one of the nitrates, ordinarily that of potash (saltpeter), but for some purposes the inventor prefers nitrate of baryta.

Another recipe for white gunpowder consists of equal parts of chlorate of potash, white sugar, and ferro-cyanide of potassium. Mix very cautiously, as it explodes by percussion. It is exploded by a red-hot body or a drop of sulphuric acid.

The following table shows the first recorded use in making gunpowder of the ingredients stated.

Charcoal, sulphur, and nitrate of potassa	*Time immemorial.*	Aloes	1869
Bituminous coal	1838	Fats and oils	1871
Bark (morus)	1855	Lime	1831
Peat	1856	Phosphorus	1864
Cork (burned)	1856	Bisulphide carbon	1863
Lycopodium	1856	Ferro-cyan. of potassa	1850
Horse-dung	1853	Chlorate of potassa	1850
Sawdust	1856	Carbonate of potassa	1859
Sugar	1856	Bichromate of potassa	1864
Tan	1858	Carbazotate of potassa	1868
Starch	1858	Azotate of potassa	1868
Flour	1858	Chloride of sodium	1856
Bran	1858	Nitrate of sodium	1857
Gum	1859	Sulphate of sodium	1862
Cannel coal	1861	Potasso-tartrate of sodium	1864
Caoutchouc	1863	Barilla	1864
Dextrine	1864	Carbonate of sodium	1864
Petroleum products	1864	Chlorate of lead	1862
Lamp-black	1865	Red sulphate of arsenic	1850
Cutch and gambier	1866	Sulphate of magnesia	1862
Grahamite	1869	Nitrate of strontian	1862
Paraffine	1869	Nitrate of baryta	1862
Logwood	1869	Nitrate of lead	1864
Carbolic acid	1869	Nitrate of iron	1869
Tannin	1869	Binoxide of manganese	1864
		Cyanuret of zinc	1864

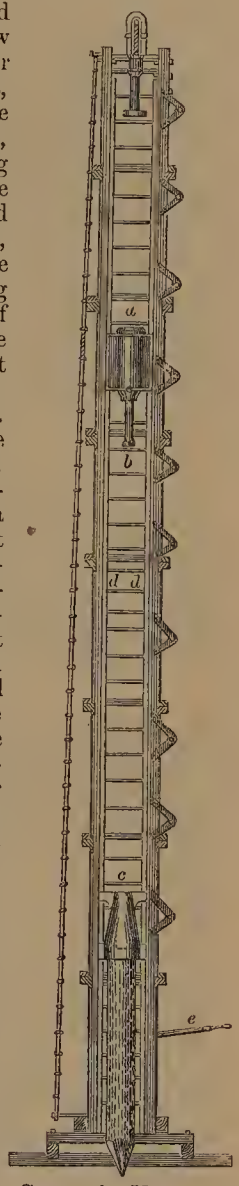
Gun'pow-der-en'gine. A form of gas-engine in which the motion of the piston is caused by the evolution of gas resulting from the combustion of gunpowder. D'Hautefeuille worked upon this problem, using the gas to obtain a partial vacuum in a chamber; the exploding of the gas expelled the atmospheric air, and the gases suddenly condensing left the vessel nearly void.

Huyghens adopted the same principle, but used a cylinder for his explosive chamber, the vacuum being utilized by the resulting atmospheric pressure upon the piston moving in the cylinder. Papin substituted a bell-valve over a hole in the middle of the piston for the leather tubes used by Huyghens.

In 1791, Barker patented a gas-engine having the main features of the modern gas-engine; streams of carbureted hydrogen gas and atmospheric air being introduced through different conductors into a cylinder, in which the gas was exploded, the effect being to drive a piston. See GAS-ENGINE.

Papin's apparatus consisted of a tube closed at bottom and having a valved piston below which a charge of gunpowder was exploded. The idea was, that the sudden blast of the explosion would expel the air, causing a vacuum and allowing the full atmospheric pressure to operate on the downward stroke. This was, however, not realized in practice, the pressure actually not being found to exceed half that of the atmosphere, owing to the non-production of a perfect vacuum by this means.

Fig. 2345.

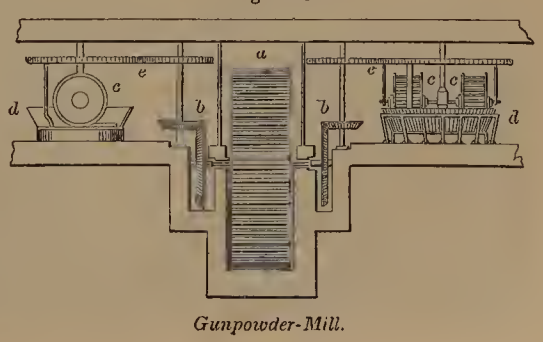


Gunpowder-Hammer.

Gun'pow-der-ham'mer. A pile-driver operated by the explosive force of gunpowder. The hammer *a* is, as usual, arranged to slide in guides in a vertical frame. It is bored out cylindrically in the upper central part, and has a plunger *b* below. The pile-cap *c* has a cylindrical hollow in its upper part for the reception of this piston and a cartridge, and a conical seat below to fit the head of the pile. It is also fitted to the guides *d d*. The lever *e* is connected by a rope with a trigger at the upper part of the frame, by which the hammer is held in an elevated position. A cartridge is placed in the pile-cap *c*, and the piston allowed to drop, compressing the air contained in the cap *c* sufficiently to ignite a cartridge placed therein. The explosion throws up the hammer, which again drops by its gravity, and so on. The powder used is composed of 1½ parts chlorate of potash and 1 bituminous coal, finely pulverized and intimately mixed. The charge is very small, one third of an ounce sufficing to operate a hammer of 675 pounds' weight. The piston, at the upper part of the machine, enters into the cavity in *a* and acts as a buffer, preventing injury to the machine and assisting the downward movement of the hammer.

Gun'pow-der-mill. Fig. 2346 shows an arrangement by which several gunpowder rolling-mills are driven from a water-wheel *a* by bevel and spur-gears *b b e e*. The cast-iron or stone rolling-cylinders

Fig. 2346.

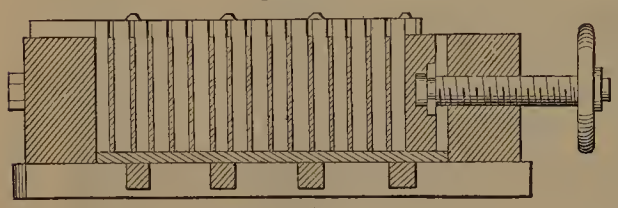


Gunpowder-Mill.

c c revolve on a horizontal axis which is carried around by a vertical shaft within the circular trough *d*, into which a charge, usually 75 or 150 pounds, of the incorporated materials from the rolling barrel has been placed. The rollers are set in motion, slowly at first, and afterwards more rapidly, and kept going three hours for a charge of 150 pounds, or for a less quantity a proportionately less time, a little water being added to prevent danger of explosion should the materials become too dry. A scraper follows each roller to keep the composition exposed to the action of the rollers. At the end of this time the mass has become thoroughly incorporated, is of a brownish red color, and is termed *mill-cake*. See GUNPOWDER.

Gun'pow-der-press. For pressing *mill-cake* into hard cake preparatory to granulating. That illustrated is particularly designed for compressing

Fig. 2347.



Gunpowder-Press.

dust-powder into hard cakes between upright plates which are adjustably arranged in the box by means of a gage-bar. The pressure is applied by a follower operated by a horizontal screw.

Gun-room. (*Nautical.*) The purpose of this room, at the after end of the lower gun-deck, differs according to the rate of the vessel and also in different services.

In war vessels of moderate size it is occupied by the lieutenants and some other officers. In vessels of larger size the lieutenants occupy the *ward*-room, and the junior officers the gun-room.

Gun-search'er. An instrument with several projecting prongs to ascertain whether the bore of a gun be honeycombed.

Gun-stock. The part of a gun to which the barrel and lock are fastened. It is usually of walnut; in Europe the *Juglans regia*, in America the *Juglans nigra*.

Gun-stocks, until the invention of the Blanchard lathe, were made by hand in a laborious and tedious manner. This machine was introduced into the Springfield Armory about 1820.

A rough chunk of wood is placed in the first of the stocking machines, from whence it emerges with its sides cut to the proper shape for turning. In another machine its butt-end is sawed, and a diagonal line cut at the breech. The third, armed with two circular saws, fashions the upper part of the stock in its finished form. Another machine reduces the butt to its ultimate shape. Another simply planes various places in the sides of the stock as points for the working of yet other machines, — an operation which is known as *spotting*. A sixth machine performs six distinct items, called *grooving* for the barrel, breech-pin, and tang; *heading* down, *milling*, and *finish-grooving*. The stock is at this stage prepared for the *fitting* in of the barrel. A seventh machine planes the top, bottom, and sides, while the eighth and ninth do the *shaping* and *bedding* for the butt-plates. The next machine prepares the stock for the reception of the lock. Another machine is used to cut for the guards, to bore for the side screws of the lock, and two more to make places for tips and bands. After these various operations comes the second turning and smoothing of the work; then the grooving for the ramrod; then the boring for the ramrod from the point at which the groove ends. These machines are each provided with a pattern or templet, which is the exact counterpart of the cavity or other form to be produced in the stock. They are furnished also with cutters or borers, which, being placed above the stock, are made to revolve rapidly and cut the wood in exact imitation of the pattern below. The movements of the tool are controlled by a guide which is inserted within the pattern. The tool is made to revolve by means of small machinery within its frame, the latter and all within it moving together with both lateral and vertical motions, being governed by the guide, which is connected with it, by the aid of very curious and intricate machinery.

The work of the artisan, when the machine is in motion and the stock is adjusted in its bed within it, beneath the borers or cutters, is simply to bring the guide down into the pattern, and move it about the circumference and through its center. The cutting-tool follows the movements of the guide, and the result is a perfect duplicate in the stock of the form in the mold below. See LATHE FOR TURNING IRREGULAR FORMS.

Gun-tack'le. (*Nautical.*) The ropes and pulleys attached to the sides of the ports and to the gun-carriage by which the gun is run out. It consists of two single blocks, one movable and the other fixed, the standing end of the fall being secured to the movable block.

Gun'ter's Chain. A surveyor's chain 66 feet or 4 rods (of 5½ yards each) in length, having 100 links, each joined to the adjacent one by three links. A square chain is $\frac{1}{10}$ of an acre, or 10,000 square links.

It was invented by the Rev. Mr. Gunter (1581–1626), of England, to aid in calculating areas.

Gunter's Chain.

7.92 inches = 1 link.
100 links = 1 chain, 4 rods, or 22 yards.
80 chains = 1 mile.

Gun'ter's Scale. A large plane scale invented by Mr. Gunter of England. It has various lines of numbers engraved on it, by which questions in calculation, navigation, and surveying are solved mechanically by the aid of the dividers or a slider.

On one side of it are scales of equal parts, chords, sines, tangents, rhombs, etc.; on the other side are the corresponding logarithmic lines.

It consists of a flat ruler of boxwood, two feet long, having various lines laid down upon it, by means of which various problems may be performed by the extension of the compasses only. This will be best explained by a description of the line called the *line of number*, or Gunter's line, which is adapted to the solution of arithmetical questions, and exhibiting a few practical examples.

The *line of numbers* is the logarithmic scale of proportionals, which, being graduated upon the ruler, serves to solve problems in the same manner as logarithms do arithmetically. It is usually divided into 100 parts, every tenth of which is numbered, beginning with 1 and ending with 10, so that if the first great division stand for the $\frac{1}{10}$ of an integer, the next great division will stand for $\frac{2}{10}$, and the intermediate divisions will represent 100ths of an integer, whilst the large divisions beyond 10 will represent units; and if the first set of large divisions represent units, the subdivisions will represent 10ths, whilst the second set of large divisions will represent tens, and the subdivisions units, etc.

The general rule for using this instrument is as follows: Since all questions are reducible to proportions, if the compass be extended from the 1st term to the 3d, the same extent will reach from the 2d to the 4th term.

The following are a few examples of some of the uses of this line:—

1. To find the product of any two numbers, as 4 and 8: extend the compass from 1 to the multiplier 4, and the same extent applied the same way from 8 the multiplicand will reach the product 32.

2. To divide one number by another, as 36 by 4: extend the compass from 4 to 1, and the same extent will reach from 9 to 36.

3. To find a fourth proportional to three given numbers, as 6, 8, and 9: extend the compasses from 6 to 8, and this extent laid the same way will reach to 12, the fourth proportional required.

4. To extract the square root of a number, say 25: bisect the distance between 1 on the scale and the point representing 25; then half this set off from 1 will give the point 5, which is the root required.

In the same manner the cube-root or the root of any higher power may be found by dividing the distance on the line between 1 and the given number into as many equal parts as the index of the power expresses, then one of those parts set from 1 will extend to the number representing the root required.

An improvement which has rendered the compasses unnecessary consists in having two lines of numbers placed one over the other, one of which lines is engraved upon a slider moving in a groove and is applied as follows: —

The 1st term of the proportional upon the slider being set against the 3d term on the fixed scale, the 2d term upon the slider will stand opposite the 4th term upon the fixed scale.

Instruments of this description with scales suited to almost every branch of art in which calculation is required are now common among intelligent workmen, and the scale of chemical equivalents by which the labors of the chemist are so much facilitated is constructed upon the same principle.

Gun'wale. The upper planking covering the timber-heads round the ship.

A piece of timber around the top side of a boat, and having rowlocks for the oars.

Gur-glet. A porous earthen jar for cooling water. See ICE-MAKING MACHINE.

Gur'let. (*Masonry, etc.*) A pickaxe with one sharp point and one cutting-edge.

Gur'mie. (*Mining.*) A level or working. See GUNNIE.

Gus'set. 1. An angle-iron or bracket stiffening the angle of a structure.

2. An angular piece of iron inserted in a boiler, tank, etc., where it changes from a cylindrical to a square form, etc., as in the junction of the barrel and fire-box of a locomotive.

Gut. 1. Prepared sheep's entrails. See CATGUT.

2. The sac of silk taken from the silk-worm and stretched into a line for a snood.

Gut'ta. One of the ornaments resembling drops, placed in the epistylium of the Doric order below the triglyphs.

Gut'ta-per'cha. The hardened juice derived from the Isonandra, gutta-tree. It is said to take its name from the Malay words *gutta*, gum, and *percha*, the particular kind of tree which yields the juice. The tree is indigenous to the islands of the Indian Archipelago, and particularly to the Malayan peninsula, whose inhabitants have long used the gum for spear handles and other objects, formerly cutting down the tree for this purpose, but now, instructed as to its commercial value, collecting the juice in bowls or cocoa-nut shells from incisions made in the tree. It very soon hardens, and is ready for manufacture. It was first made known by Dr. Montgomery, in 1843; about the same time some was brought to London by Dr. D'Almeida. The former gentleman was rewarded by the London Society of Arts with a gold medal.

The juice consolidates in a few minutes after being drawn, and is then formed by the hand into oblong masses about seven inches long and six inches thick. These generally contain bits of wood and other impurities, which may be removed by immersion in boiling water until the mass is sufficiently softened to be rolled out into a thin sheet, when they may be picked out by hand. Its plasticity when heated allows it to be readily molded into various forms, such as vessels for holding liquids, etc., which are made and offered for sale by the natives.

It is completely unaffected by cold water, and is insoluble in boiling alcohol, but may be readily dissolved by boiling spirits of turpentine, also by coal-tar or naphtha. It resists alkalies and acids, being only affected by the nitric or sulphuric in a highly concentrated state, and is a non-conductor of heat and electricity.

Though applicable to many of the purposes for which india-rubber is employed, it differs greatly from that gum in many respects, being lighter, of finer grain, and very tough and unyielding. Its appearance in the crude state is also very different, the color being a grayish white.

The peculiar adaptability of gutta-percha to many kinds of surgical appliances, and to coating telegraph-cables, is well known.

The mode of manufacture is simple.

The first process consists in cutting the masses into thin slices by means of a vertical wheel whose face has fixed cutters.

These slices are then thrown into a steam-heated tank, by which they are softened, depositing the dirt and heavier impurities, after which the mass of gum in a pasty condition is transferred to another rotary machine provided with teeth, by which it is torn into fragments. These fall into a tank of water, on which they float, any remaining impurities falling to the bottom. The fragments are next softened to a dough-like consistency by immersion in hot water, and thoroughly kneaded by being placed in heated hollow cylinders, within which rotating drums mix the plastic mass and impart to it a uniform consistency. It is now ready for being drawn into sheets or tubes. In forming sheets the mass is passed between steel rollers at a distance apart corresponding to that of the sheet to be made; by this time it has cooled to a solid consistency, and may, by means of adjustable knives, be cut into strips of any desired width before leaving the machine. In making tubes, the gum while yet soft is placed in heated cylinders and forced through hollow molds in a manner similar to that used in making clay drain-pipes. For stamped articles the sheets are cut into appropriately sized pieces, which are heated and compressed between dies. In coating telegraph-wires several of the wires are laid parallel, a strip of gutta-percha is placed above and another below them, and the whole is passed between two polished grooved rollers. The pressure binds the two surfaces of the gutta-percha firmly together and to the wires, while the ridges between the grooves indent the gum so deeply that it may be easily separated longi-

tudinally, each strip containing its own core of copper.

Gut'ta-per'cha Plates. Forms for the ordinary printing-press taken with gutta-percha. An intaglio impression is taken from the form. This, when cold, forms a matrix for obtaining a cameo gutta-percha impression which is used in the press.

Gut'ter. 1. (*Hydraulic Engineering.*) The trench made to hold puddling on the side of a canal.

2. A channel or ditch alongside a traveled road or path to lead off surface water.

3. (*Architecture.*) A trough or channel collecting the water which runs from a roof and leading it to pipes in which it descends to the earth.

A (Fig. 2348) shows the usual arrangement of gutters in England, where parapets are generally carried up above the supporting wall.

This appears, and is said to be, very productive of leakage and injurious to the woodwork of the roof. The Greek or Gothic eave is much better; let the water go, and catch it afterwards if you want to.

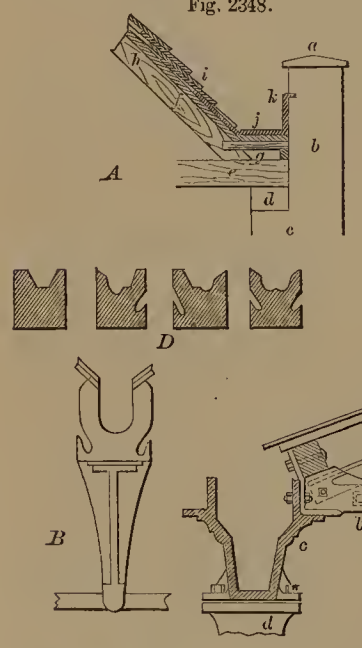
a, *coping*.
b, *parapet*, the outer edge *throated*.
c, *wall*.
d, *wall-plate*.
e, *joist*.
f, *rafter*.
g, *gutter-board*.
h, *eave-board*.
i, *slates or shingles*.
j, *gutter*.
k, *flashing*.

B is the form of gutter, scored out of a solid piece of timber, which was used in the London Crystal Palace of 1861. It was supported on the upper flanges of the main trusses.

C is the arrangement adopted at the Smithfield Market, Manchester, England. The principal rafter *a* and tie *b* rest on the cast-iron gutter *e*, which is supported by the column *d*.

D exhibits several forms of top and side gutters worked out of the solid.

Fig. 2348.



Gutters.

4. (*Hydraulic Engineering.*) A device (*E*, Fig. 2348) for raising water by the vertical oscillation of a trough. As a crude and cheap device it is represented in the accompanying cut, which does not need lengthy description. As a more important machine it is shown under BAIL-SCOOP (which see). It is principally used for small lifts, but by a succession of lifts it may be useful for higher elevations.

The *jantu* of the Bengalese is a counter-weighted *gutter*.

A pendulous *gutter* with several steps of ascent for water is shown in Ewbank's hydraulics.

5. (*Printing.*) One of the *sticks* placed between the pages in a *form* to separate them to such a distance that when the sheet is printed and folded the margin shall be regular and uniform.

Gut'ter-ledge. (*Nautical.*) A bar laid across a hatchway to support the covers.

Gut'ter-snipe. (*Printing.*) A single slip-poster for attaching to curbstones.

Gut'ter-stick. (*Printing.*) One of the pieces of furniture which separate the pages in a form.

Guy. 1. A stay-rope passing from the top of a spar to a post or anchor in the ground, and used to steady it. As the *guys* of a *derrick* or *shears*. See DERRICK; SHEARS.

2. The stay-rod which connects the floor of a suspension bridge with the land on each side, in order to prevent swaying.

3. A rope to steady a body in hoisting.

4. A rope which trims and steadies a *lower studding-sail boom*. The *fore-guy* leads from the boom-end to the *spritsail-gaff*, thence to the heel of the bowsprit, and thence inboard; the *after-guy* leads from the boom-end to a sheave in the ship's side, and thence inboard.

5. A rope from the end of a jib-boom or flying jib-boom to the end of a *spritsail-yard* or *spritsail-gaff*, and thence to the ship's bow, to stay the spar laterally.

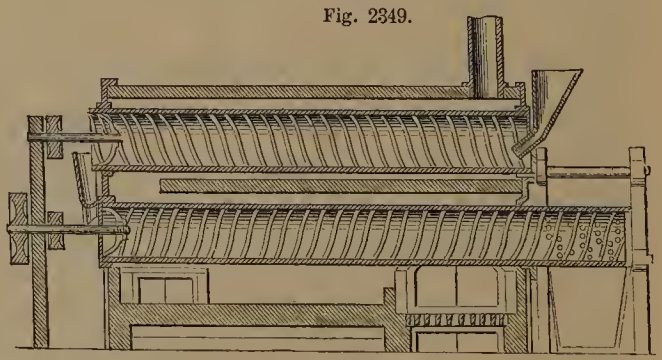
Gybe. (*Nautical.*) The shifting over of the boom of a fore-and-aft sail.

Gyle. 1. Fermented wort for making vinegar.

2. A large vat or cistern. The liquor gyle in a brewery is the water-cistern or vat. A *gyle-tun*.

Gyp'sum-fur'nace. A furnace in which natural gypsum, a hydrate of sulphate of lime, is calcined at a comparatively low heat — about 300 F. — in order to drive off the water of constitution. The process is called *boiling*, as the ebullition is very marked. In the illustration is shown a furnace containing

Fig. 2349.



Gypsum-Furnace.

two rotary boilers placed one over the other and provided with rotary conveyors. The gypsum is fed through the boilers consecutively, and is thence emptied upon a cooling surface and packed in barrels.

Gy'ro-scope. An instrument for illustrating the tendency of a revolving body to maintain its

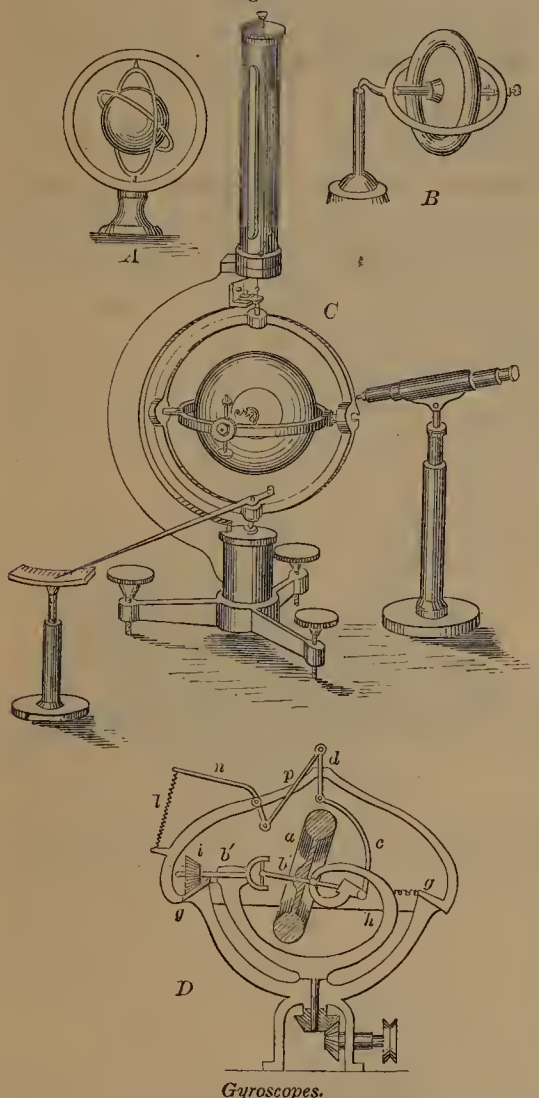
rotation in a fixed plane when free from the influence of disturbing forces.

It is susceptible of various forms. The earliest, probably, was that of Laplace, for illustrating the precession of the equinoxes.

The principle involved is that of Galileo's second law of motion, that a body actuated by several forces moves in the direction of their resultant.

Several centuries back the Italian academicians noticed the apparent displacement of the plane of vibration of the pendulum. Foucault (1852) first

Fig. 2350.



Gyroscopes.

connected this fact with the diurnal motion of the earth, which he illustrated by means of a pendulum (see PENDULUM) and a gyroscope contrived by him.

Bohnenberger's (1765–1831) apparatus (*A*, Fig. 2350) consists of a disk or sphere suspended in gimbals, which are mounted in a ring supported on a stand.

The interior ball and ring may be set at any angle with the outer one, and rotation imparted by a string, when it will be found strongly to resist any attempt to turn it from the plane of its rotation. This disposition of a rotating object to maintain its revolutions in one plane, designated as fixity or persistence of the plane of rotation, may be farther illustrated by the tendency of a trundling hoop or rotating top to remain upright, and by the directness of flight of rotating projectiles.

About 1832, Professor W. R. Johnston, of Philadelphia, devised an instrument which he termed a *rotoscope*, for illustrating this principle. He also showed the effect of rotary motion in overcoming the force of terrestrial gravity by the device shown at *B*, Fig. 2350.

In this a disk is pivoted within a ring, its axis is extended and turned down, so that one end may be supported in a depression at the top of an upright standard. When the disk is placed vertically and rapid rotation imparted, it will maintain its rotation around the standard in a horizontal plane so long as its velocity is considerable, but when this ceases it falls.

C illustrates Foucault's gyroscope for demonstrating the rotary motion of the earth.

A carefully constructed disk is delicately suspended in gimbals within an outer ring vertically pivoted in a frame. The disk is brought into the plane of the meridian and rotated at a great velocity by machinery capable of instantaneous disconnection.

As the plane of the meridian at the moment of starting the apparatus coincided with some celestial meridian, the gyroscope will, while it maintains its rotation, keep in the plane of the latter, that is a fixed line in the heavens, while the terrestrial meridian is carried past it at the rate of 15° per hour. This is shown by a graduated horizontal arc affixed to the gyroscope, which is viewed through a telescope whose axis is fixed in the plane of the terrestrial meridian. It is obvious that were the earth a fixed body the axis of the telescope would always coincide with the same point on the arc, but the latter always maintaining the same vertical plane in space while the direction of the former is constantly changing with the diurnal revolution of the earth, the arc will appear to move in a direction contrary to the earth's rotation.

Gy'ro-scope-gov'ern-or. In Anderson's governor (*D*, Fig. 2350) the principle of the gyroscope has been adapted as the means of regulation.

a is a heavy wheel, the axle *b b'* of which is made in two pieces connected by a gimbal joint, the respective sections carrying the wheel *a* and pinion *i* respectively. The piece *b* is connected at its middle by a hinge joint with the revolving frame *h*, so that variations in the inclination of the wheel *a* will cause the outer end of the piece *b* to rise and fall. The frame *h* is driven by bevel gearing from the engine, and by that means the pinion *i* is carried round the stationary, toothed circle *g*, and the axis of the wheel *a* thus receives a rapid rotation. When the frame *h* and wheel *a* are in motion, the tendency of the wheel *a* is to assume a vertical position, but this tendency is opposed by a spring *l*. The greater the velocity of the governor, the stronger is the tendency above mentioned, and the more it overcomes the force of the spring, and *vice versa*. The piece *b* is connected with the valve-rod by rods *c d*, and the spring *l* is connected with the said rod by lever *n* and rod *p*.

Gyves. Shackles or fetters.

H.

Ha'beck. An instrument used in dressing cloth.

Hack. 1. A tool for cutting jags or channels in trees for the purpose of bleeding them. Pines are *hacked* for turpentine; maples *tapped* for *sap*, or *sugar-water* as Western farmers prefer to call it.

The turpentine hack is a tool with a curved or angular edge to cut channels through the bark and alburnum in an oblique direction, so as to lead the resin towards a *boxing* cut in the tree, or to a cup suspended to catch the drip.

2. A drying-frame for fish. A *flake*.

3. A *pile* of bricks arranged in regular order for *drying*, previous to building up in the *clamp* or *kiln* for *burning*.

4. Wooden bars in the tail-race of a mill.

5. A dung-fork.

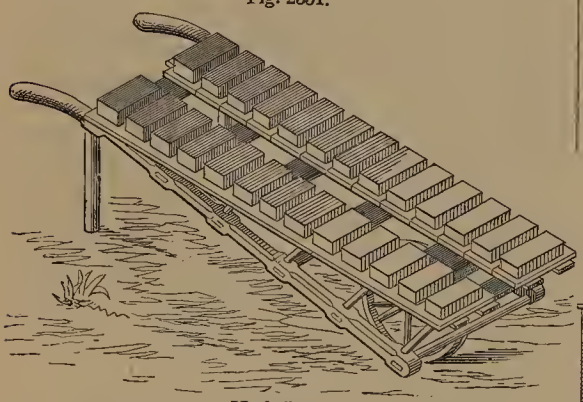
6. A large pick used by miners in breaking stone.

7. A carriage for hire (hackney-coach).

8. A feed-rack for cattle.

Hack-bar'row. A barrow on which bricks are conveyed from the molder's table to the drying-ground, where they are sun-dried or *hacked*, and

Fig. 2351.



Hack-Barrow.

temporarily covered with a thatching of straw to protect them from rain. Covered sheds are sometimes used.

Hack'but. (Ger. *hackbret*, a *hackboard*, or chopping-board.) An old name for the *dulcimer*. See PIANO-FORTE.

Hack'er. A cutting-tool for making an oblique incision in the pine-tree for leading the gum turpentine towards the *box* in which it is collected. A *hack*. The *round-shave* is used in chipping, and the *scraper* for removing the gum from the *box face*.

Hack'er-y. An East Indian two-wheeled cart, drawn by bullocks.

Hack'et. (*Joinery.*) A hatchet.

Hack-file. (*Locksmithing.*) A coarse slitting-file.

Hack-ham'mer. A hammer terminating at each end in an obtuse chisel-edge, kept in repair on the grindstone. It is used as the *peen* of an ordinary hammer, but is narrower, and therefore more local and energetic in its effects. The *hack-hammer* for reducing unequal protuberances on grindstones is shaped like an adze and has a short handle. When the grindstone has worn unequally, it becomes necessary to dress it, and the high places, being marked, are hacked by oblique and crossing checker lines, which cause it on the next grinding operation to wear more at those points and thus restore equality.

Hack'ing. 1. (*Masonry.*) The division of a portion of a course of stones into two of smaller hight when the larger stones do not hold out.

2. A process employed in dressing the faces of rough grindstones by the use of a hack-hammer, an implement resembling an adze. In some cases the faces of metallic or wooden polishing-wheels are similarly treated, a sharper implement being used.

3. Piling of molded bricks to dry. See HACK.

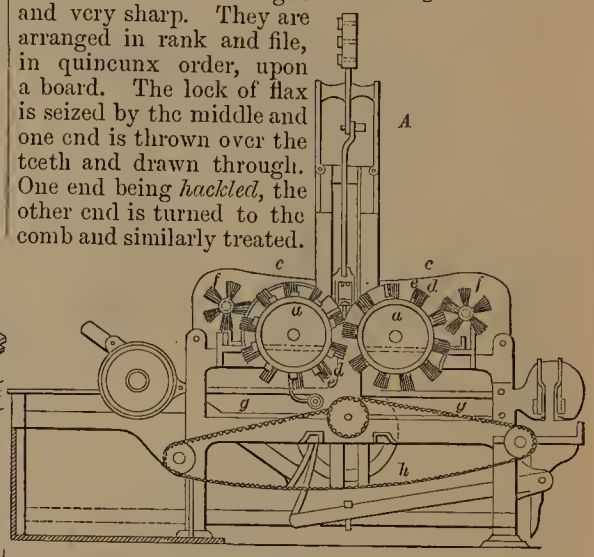
Hack'ing-out Knife. The glazier's knife for cutting out the old putty from the fillister of a sash, in reglazing.

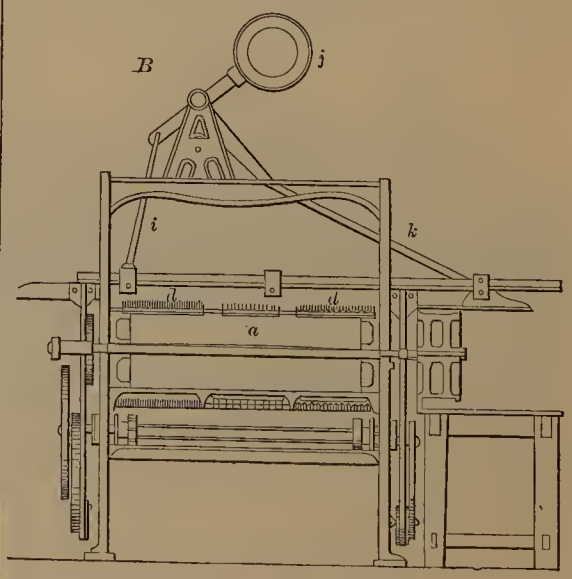
Hack-i'ron. (*Mining.*) A miner's pick. A *hack*.

Hack'le; Heck'le; Hatch'el. A board set with sharp steel spikes for combing or pulling out hemp or flax to dispose the fibers in parallelism, and to separate the *tow* and *hards* from the finer fiber.

The teeth are of steel from 1 to 2 inches in length and very sharp. They are arranged in rank and file, in quincunx order, upon a board. The lock of flax is seized by the middle and one end is thrown over the teeth and drawn through. One end being *hackled*, the other end is turned to the comb and similarly treated.

Fig. 2352.





Hackling-Machine.

This separates the ribbons of fiber, removes any remaining traces of the *boon* or cellular matter, and divides the fiber into two portions, the *short* and the *long*, the *tow* and the *line*.

The process is repeated on a fine hackle whose teeth are more numerous and thickly set. The produce is from 40 to 60 per cent of fine flax; *line*.

Hack'le-bar. One of the *gills* or spikes over which the lock of flax or hemp is thrown and drawn to lay the fibers parallel and comb out the refuse.

Hack'ling-ma-chine'. A machine for dressing flax.

Fig. 2352, *A* is a side and *B* an end elevation of a hackling-machine adapted for dressing short or cut flax. The two rollers *a a* are caused to rotate inwardly toward each other, and are fed with the raw material from a trough *c*. The peripheries of the cylinders are interspersed with alternate rigid hackles *d* and brushes *e*, so that they alternate on each. The exterior rotating cylinders *f* are also provided with brushes. The broken flax from an upper trough passes between the rollers and is deposited in the trough *g*. Refuse falls between the bars of a grate, and is removed by the endless carrier *h*. One of the cylinders *a* and the brushing cylinders *f* may have a longitudinal movement. On raising the receiving-trough, the rod *i* pushes up the weight *j*, which, by means of the connecting-rod *k*, causes the holder to traverse the width of one set of brushes.

Hack'ney-coach. (*Vehicle.*) An English term for a coach plying in the streets for hire. It has two facing seats inside.

Fig. 2353.

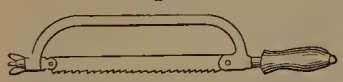
The First (English) Hackney-Coach.

They were introduced into France in 1650 (*fiacre*), and about the same time into England. They are mentioned by Pepys, 1660.

The name is French (*coche-à-haquenée*).

Hack-saw. A frame saw of moderate set, tolerably close teeth, and good temper; used in sawing metal. Such a saw is used to cut the nicks in heads of screws, in cutting off bolts, etc.

Fig. 2354.



Hack-Saw.

Hade. (*Mining.*) The *dip*, *inclination*, or *slope* of a vein or stratum. The angle it bears to the horizon. The *underlay*.

Had'ley's Quad'rant. (*Optics.*) An instrument for measuring altitudes. Used principally at sea. See QUADRANT; SEXTANT.

Hag'but. An old fire-arm with a stock bent down to form a ready means of grasping. An *arquebus*.

Hæm'a-dyn-a-mom'e-ter. An instrument for ascertaining the force of the circulation of the blood. *Hæmatometer; hæmatodynamometer*. See SPHYGMOMETER.

Haft. The handle of a tool or knife. Some handles have specific names, as *helve*, *nib*, etc. Some hafts are solid, others have a central plate and side pieces called *scales*; e. g. knife-handles.

Ha-ha. A fence or division wall so depressed below the ground surface as not to obstruct the view. A *sunk-fence*. A ditch with a *scarp*.

Hair. 1. A filament growing from the skin of an animal.

Curled hair for stuffing sofas, cushions, etc., is carded by hand-cards, which straighten, disentangle, and clean it; this is taken in bunches and spun into a rope, the next *top*, as the bunch is called, being interplaced with the loose strands of the former. The rope is wound on a wheel, and the coil steeped in water for three or four hours, and dried in a hot oven. The ropes are then untwisted, the hairs torn apart, and are ready to form stuffing.

Spun into smaller strands, hair is used for *nose-bags* of horses, bags for containing ground and heated flax-meal in the press, and also for containing prepared lard in the press from which lard-oil flows.

Curled-hair cords are also used for clothes-lines, and when fine also form fishing-lines.

Long and fine horse-hairs are used for the bows of violins and other instruments of this class. Also for making HAIR-CLOTH (which see).

The English lawyers affect horse-hair wigs, and horribly funny they look. Goat's hair is sometimes substituted for the true equine capillus, and this may partially account for their pugnacity and the fact that they are in bad odor with peaceable persons.

2. (*Fire-arms.*) The secondary spring device in one form of pistol and rifle lock, which is freed by the hair-trigger, and collides with the tumbler-catch to unlock the tumbler.

Hair-brush. A fine description of brushes of bristles assorted by color, strength, and quality, and put up in superior manner, hard, soft, or silky, according to purpose and taste. The better class are *trepanned*, a mode of secretly fastening the bunches without gluing a scale of veneer over the wires.

Hair-clip'ping Shears. A scissors for clipping the human hair, or one for clipping horses; the latter have sometimes a guide-bar, which forms a gage for length in cutting.

Hair-cloth. Cloth of goat's hair was used for covering the military engines of the Romans, as we read in Arrian, Thucydides, Ammianus, etc. Curtains of goat's hair were used in the Wilderness tabernacle of the Hebrews. The goat's hair cloth was called *shae* or *sae* in Hebrew, Chaldee, and Syriac; in the Septuagint it became *saccos*; in the Vulgate *saccus*. The Latin *sagum* and English *sack* perpetuate the sound and sense. (See SACK.) The nose-bags of the Arabian horses are of goat's hair cloth, and from them they eat their barley habitually. Goat's hair cloth also covers their tents. See also CAMLET.

Horse-hair for the manufacture of hair-cloth is principally derived from South America, and is imported in bales weighing about 1,000 pounds.

In the process of manufacture, it is first sorted according to color, and then hackled to get the hairs straight and remove dirt. A number of tufts are then placed between the teeth of two cards, and the longer hairs removed by hand, so as to leave only those of uniform length remaining. It is now ready to be woven or curled, according to quality. Hair is curled by forming it into a rope which is afterwards boiled, and then baked so as to set the kink in the hairs.

Hair-cloth is made from the longer and better varieties. The hair is first dyed, usually of a black color, and is merely employed as the weft of the cloth, the warp being composed of cotton or linen thread, according to quality and purpose. The process for-

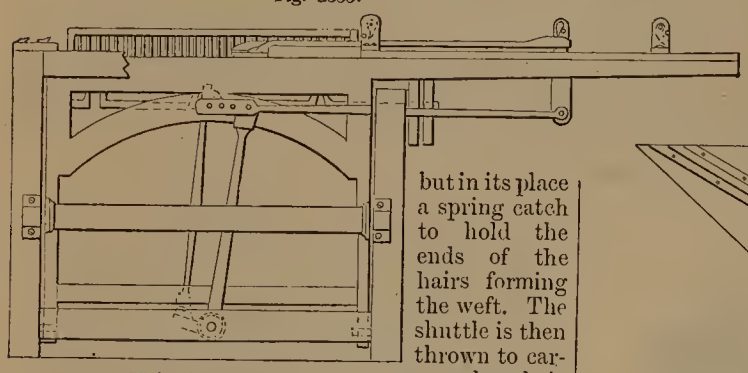
merly required two hands to each loom, but those at present used only require the attendance of one person, and recently power-looms have been employed.

After leaving the loom, the cloth is pressed between hot metallic plates to polish it.

Hair-cloth Loom. The *warp* of the web is of black linen yarn; the hair *weft* is thrown with a long hooked shuttle or a long rod having a catch hook at its end. The length of this boxwood shuttle is about 3 feet, its breadth ½ inch, and its thickness ⅛ inch. The *reed* is of polished steel. The weaver passes the shuttle through the *shuttle-way* when it is opened by the treadles; a child presents a hair to the catch of the shuttle, and the weaver draws it through the *shed* and beats it up by two motions of the *batten*. The hairs are laid in a trough of water to keep them supple. The warp is dressed with paste, and the hair-cloth web is hot-calendered to give it luster.

The shuttle for hair-cloth weaving has no pin, but in its place a spring catch to hold the ends of the hairs forming the weft. The shuttle is then thrown to carry the hair through the shed; at the other end of the shuttle-way the hairs are released by raising the catch.

Fig. 2355.



Hair-Cloth Loom.

In the illustration, the moving jaws of the nippers are raised by cams to allow the introduction of the hairs, and are opened by cams at different times to drop the hairs at different positions in the shed.

Hair-com'pass. A pair of dividers, one of the legs of which is provided with a set screw and spring, admitting of very nice adjustment.

Hair-cord. (*Fabric.*) A cotton goods, the warp of which consists of corded ribs.

Hair-di-vid'er. A dividing compass having one leg arranged for minute movements by a screw; used for fine adjustments.

Hair-line. 1. The fine line or up-stroke of a letter.

2. A kind of type having all fine face-lines.

3. A fishing-line of horse-hair.

Hair-pen'cil. A fine brush for painting. Small tufts of hair inserted into quills. The hairs of the camel, fitch, sable, badger, squirrel, martin, minever, European polecat, raccoon, goat, or other animal, are used for brushes of different qualities.

A small tuft of the hairs is collected with the points all in one direction, and the bunch is bound by a strong thread, and passed point first through a wet quill, so that the point projects to the required distance. The quill shrinks tightly upon the bunch in drying.

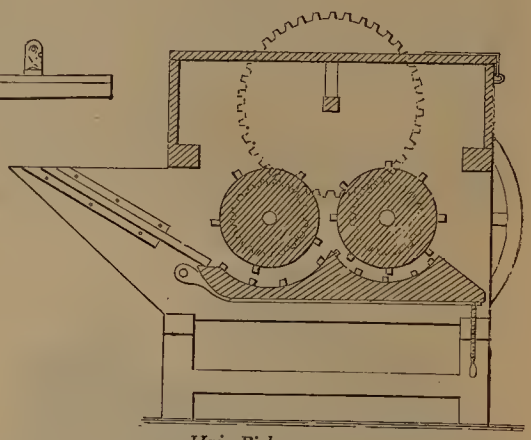
The various sizes require the quills of the crow, pigeon, goose, turkey, or swan. Larger bunches are secured in tin-plate tubes.

The ancient Greek painters used hair-pencils and palettes.

They are now principally used by artists in water-colors, and to some extent by house and sign painters in lettering, graining, and other fine work.

Hair-pick'er. A machine for cleansing and straightening hair. The one represented is for operating on loose hair. The two rollers have similar rotation by connection with a common motive wheel,

Fig. 2356.



Hair-Picker.

and turn in a double recessed, adjustable, concave block. The faces of the rollers and concave are armed with pins. The hair is straightened and dirt removed by being drawn through between the rollers and the concave surfaces.

Hair-pin. 1. A pin used in fastening up the hair. A *corking-pin.*

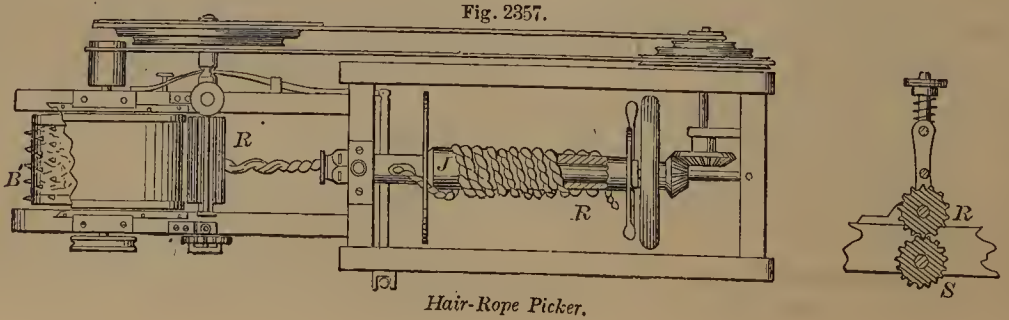
2. A forked pin commonly used by ladies in securing the braids or bands of hair.

Hair-py-ri'tes. (*Mining.*) A native sulphuret of nickel which occurs in capillary filaments of a yellow-gray color.

Hair-rope Pick'er. A machine for unwinding and picking to pieces hair-rope which has been twisted, wetted, and baked to give a permanent curl to the hair.

The rope is coiled around the shaft *J*, the revolution of which untwists it. It then passes between the fluted rolls *R S* and toothed drum *B'*, by which it is straightened and cleansed.

Fig. 2357.



Hair-Rope Picker.

Hair-salt. (*Mining.*) A native sulphuret of magnesia occurring as a fine capillary incrustation.

Hair-side. (*Leather.*) The grain side.

Hair-space. (*Printing.*) The thinnest space used by printers.

Hair-spring. The recoil-spring of a watch-*balance.*

The balance is pulsating, and is the *time* measurer. It is driven in one direction by the power of the mainspring imparted through the escapement, and is returned by the power of the hair-spring, the running of the *train* of wheels being intermitted meanwhile.

It is one of the most delicate of steel articles, and is a favorite illustration of the value given to a cheap article by protracted manipulation.

Hair-springs are made of fine steel, which comes upon spools like thread. To the naked eye it is a round hair, but under a glass it is seen to be a flat steel ribbon, which the gage shows to be $\frac{2}{2500}$ of an inch in thickness, about one half the thickness of an average human hair.

A hair-spring weighs $\frac{1}{15000}$ of a pound Troy. In a straight line it is a foot long. It is exquisitely tempered, for it is to spring back and forth 18,000 times an hour, perhaps for several generations. A pound of steel in the bar may cost one dollar; in hair-springs it may be worth $4,000.

The hair-spring of a watch is usually a flat helix, but chronometer balance-springs are coiled cylindrically.

Hooke introduced the balance-spring into the watch. He made it straight. Huyghens soon after gave it the coiled form. This was about 200 years ago. We are indebted to this brilliant pair of philosophers and mechanicians for much that we enjoy in the approximate perfection of our instruments of precision, — mathematical, optical, and horological.

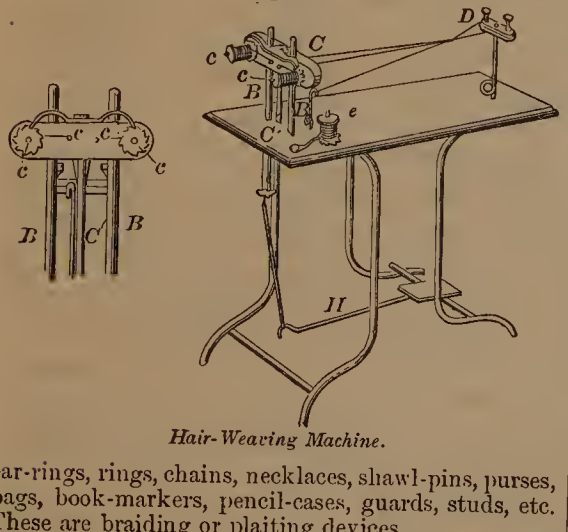
See under HOROLOGICAL INSTRUMENTS, etc.; CHRONOMETER; BALANCE, WATCH.

Hair-stroke. (*Printing.*) A fine line at the top or bottom of a letter; a ceriph.

Hair-trig'ger. (*Fire-arms.*) The secondary trigger of a gun. Its movement is effected by a very slight force, and unlocks a secondary spring device called a *hair*, which strikes the tumbler-catch and throws the sear out of the notch in the tumbler.

Hair-work'ing. A term which includes the making from human hair of bracelets, brooches,

Fig. 2358.



Hair-Weaving Machine.

ear-rings, rings, chains, necklaces, shawl-pins, purses, bags, book-markers, pencil-cases, guards, studs, etc. These are braiding or plaiting devices.

In the invention figured, designed for weaving hair for wigs, etc., the head *C*, carrying the spools *c c*, has vertical reciprocation on the pins *B B*, and is operated by the treadle *H*. The ends of the threads on the spools *c c e* are held by the clamp *D*. A slip of hair is passed between the upper side threads and the lower central one, the treadle depressed, the end of the hair turned, and the sliding head rises by the force of a spring. These operations are successively repeated.

Hake. A shed for drying draining-tiles.

Hal'berd. 1. A weapon formed of a blade on the end of a pole.

This was a common weapon among the Romans (*falx, falcula*), either short-handled like the English bill-hook, or on a long handle like the Tudor halberd. It differed from the *cultus* in having a curved cutting edge.

2. A piece of iron welded to the forepart of a horseshoe to relieve the toe of a lame horse.

Half-bas'tion. (*Fortification.*) A *demi-bastion.* That half of a bastion cut off by the capital, consisting of one base and one front.

Half-bent. The half-cock of a fire-lock.

Half-bind'ing. (*Bookbinding.*) A style of binding in which the backs and corners are of leather and the sides of paper or muslin.

Half-breadth Plan. (*Shipbuilding.*) A plan or top view of one half of a ship divided by a vertical longitudinal section in the line of the keel.

It shows the *water* lines, *bow and buttock* lines, and *diagonal* lines of construction.

Half-breadth Staff. (*Shipbuilding.*) A rod having marked upon it half the length of each beam in the ship.

Half-cap'o-niere'. (*Fortification.*) A communication in the dry ditch of a fortress, constructed with but one parapet and glacis.

Half-chess. (*Bridge-building.*) A short *chess* or platform board of a military bridge.

Half-cock. (*Fire-arms.*) The position of the gun-lock when the nose of the *scar* is in the first or deep *notch* of the *tumbler.* From this it cannot be pulled off by the trigger.

Half-cut Line. Flax cut in two lengths for spinning.

Half-floor. (*Shipbuilding.*) One of the timbers of a frame whose heel is over the keel, and upon whose head rests the heel of the second futtock. It lies for half its length alongside the cross-timber, and the other half alongside the first futtock.

Its heel butts against the heel of the corresponding timber of the other half of the frame, at the middle line of the ship, where they are clamped between the keel and keelson, and coaked or bolted thereto.

Half-fur'nace. (*Metallurgy.*) An ore-smelting furnace of but about 36 feet hight. The high furnace is 50 to 72 feet in hight.

Half-gang. (*Weaving.*) The part of warp of twenty threads, warped round the bank after a lease.

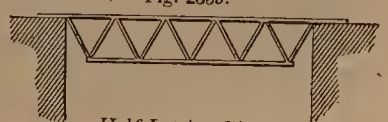
Half-head'er. (*Bricklaying.*) A half-brick laid at the angle of a building to finish the course.

Half-high Fur'nace. See HALF-FURNACE.

Half-hitch. (*Nautical.*) Passing the end of a rope round its standing part and then through the bight. A *clove-hitch* is two *half*-hitches. See HITCH; KNOT.

Half-lat'tice Gird'er. (*Bridge-building.*) A form of girder sometimes known as a "Warren Girder," and consisting of horizontal upper and lower

Fig. 2359.



Half-Lattice Girder.

bars, and a series of diagonal bars, sloping alternately in opposite directions, and dividing the space between the bars into a series of triangles. See TRUSS.

Half-mer'lon. (*Fortification.*) That solid portion of a parapet which is at the right or left extremity of a battery.

Half-min'ute Glass. (*Nautical.*) A sand-glass which determines the time for the running out of the log-line. See LOG.

Half-moon. (*Fortification.*) A *redan* in front of the *curtain* on the outside of the main ditch.

Half-moon Knife. (*Leather.*) A double-handled knife used by the dresser of skins for parchment. The knife has a crescent shape, and projects in a plane at right angles to the axis of the handles.

Half-pace. (*Building.*) *a.* A raised floor in a bay-window.

b. A resting-place at the end of a flight of steps. A *foot-pace.* A *landing.*

Half-pike. (*Nautical.*) A short pike employed in boarding.

Half-port. (*Nautical.*) A port-shutter having a hole for the protrusion of the gun-muzzle.

Half-prin'ci-pal. (*Carpentry.*) A rafter which does not extend to the crown of the roof. Their tops are connected by collar-beams, or rest on a purlin.

Half-re-lief'. The moderate prominence of a sculptured figure from the plain surface to which it is attached. It is also known as *mezzo-rilievo*, or *demi-relief*, and is a grade between *alto-rilievo* or *high-relief*, and *basso-rilievo* or *low-relief.*

Half-rip Saw. (*Carpentry.*) A species of hand-saw with a narrower set than a rip-saw and somewhat finer gage of teeth.

Half-round Bit. A demi-cylinder bit.

Half-round File. A file flat on one side and rounding on the other.

The curve usually varies from the half to the twelfth of a circle, but the name *half*-round is indiscriminately applied. Files with the larger curvature are known as *full* half-rounds; others as *flat* half-rounds.

Half-sheet. (*Printing.*) The off-cut portion of a duodecimo.

Half-shoe. (*Farriery.*) A shoe on the one side only of a horse's foot as a protection or corrective, when the horse is not fully shod.

Half-stuff. (*Paper-making.*) The partially ground rag-pulp, the produce of the *washing-engine*, which is the first of the two engines by which the reduction is made. See RAG-ENGINE.

Half-stuff Ma-chine'. (*Paper-making.*) A washing-machine in which ground rags are cleaned and cut to a greater degree of fineness than in the rag-engine. It resembles the *pulping-machine* in everything but being adapted to work on a coarser article.

Half-sunk'en Bat'tery. (*Fortification.*) A battery having its interior space or terre-plein sunk some inches below the natural surface, and its parapet composed of the earth thus obtained, and of that taken from a narrow ditch in front. This description of battery admits of being more quickly constructed than any other, as the diggers can work both in front and rear at the same time.

Half-thick File. A large, coarse file with three flat and one rounded side. It is used as a *rubber-file* for coarse work.

Half-tim'ber. 1. (*Shipbuilding.*) One of the short futtocks in the cant-body.

2. (*Carpentry.*) A mode of building houses practiced extensively in the Tudor times. The foundations and principal supports were of stout timber, and the interstices of the fronts were filled with plaster.

Half-tub. Half a cask cut off at right angles to the axis. Such is a deck tub, for swabs in deck-cleaning, and for gun-sponges on shipboard. Such is also the *match*-tub.

Half-turn'ing Bolt. One with a thread occupying one half of its cylindrical surface. See BOLT, *n.*

Hal'liard. See HALYARD.

Hal'lier. A birding net.

Hal'lo-type. (*Photography.*) Another name for the HELLENOTYPE (which see).

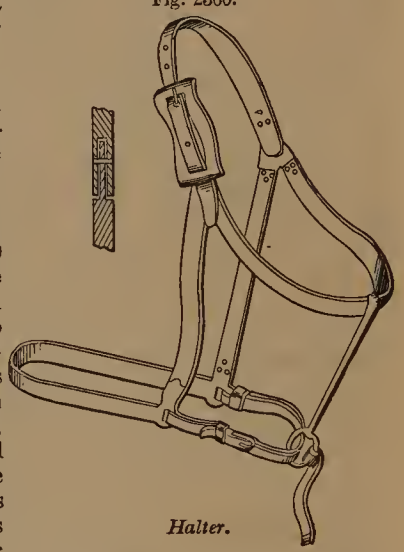
Ha-lom'e-ter. An instrument for measuring the forms and angles of salts and crystals.

Hal'o-scope. (*Optical.*) An optical instrument invented by M. Bravais for exhibiting the phenomena connected with halos, parahelia, etc. It comprises prisms and a mirror, which are rapidly revolved about an axis, and two plates of glass for intercepting the light. The rotating prisms receive the light from a lamp in a darkened chamber, the refracted rays assuming the form of the parahelion circle.

Hal'ser. A large rope. See HAWSER.

Hal'ter. (*Menage.*) A headstall and strap by which an animal is hitched to a stanchion or manger.

Fig. 2360.



Halter.

Cattle and calves were tied in stalls for fattening by the Hebrews. Horses and oxen were also stalled. Solomon had 40,000 horse-stalls. The animals were tied up by halters, no doubt. Headstalls for animals were common then in Babylon, Persepolis, and Egypt. The horses and asses of the Syrians were tied in their camp (892 B. C.) when the four leprous men went in and found the camp deserted.

Halters are shown in the sculptures of Nimroud. The army is represented in the act of crossing a river, and the horses are haltered behind the sterns of the boats, swimming in the wake.

Hal'vans. (*Mining.*) Impure ores which require to be washed and freed from impurities.

Halve-net. A fixed bag-net placed within low-water mark to prevent fish returning with the tide.

Halv'ing. A mode of joining timbers or scantling in which each is equally cut upon one of its faces, and the two new faces are laid together and secured. The timbers *lap* upon and are *let into* each other.

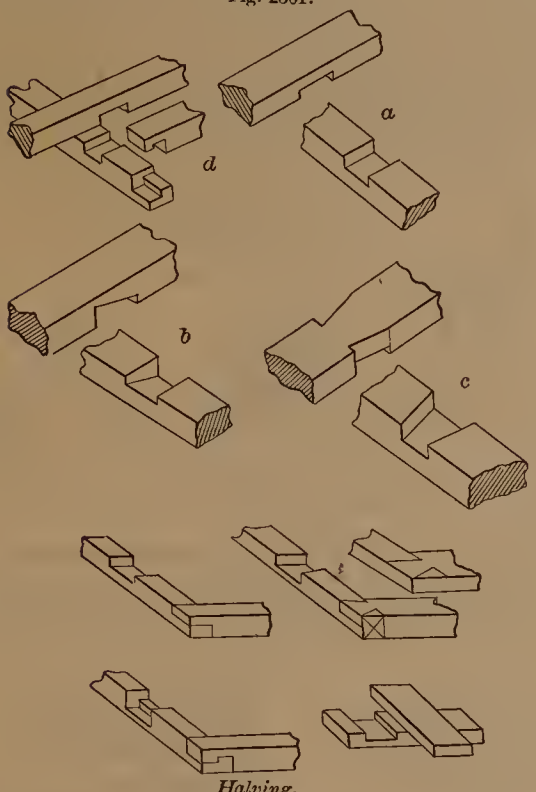
The joint thus made may be a simple *lap-joint*, or it may be a *dovetail*, a *scarf*, or a *notched joint.* It may be secured by *pins*, *wedges*, or *bolts*, according to circumstances.

Among the varieties specific names are given to *a*, *common* halving; *b*, *beveled* halving; *c*, *dovetailed* halving; *d*, *notched* halving.

Halv'ing-belt. (*Machinery.*) A belt crossed between pulleys, so as to revolve them in opposite directions. A *crossed* belt. See BELT.

Hal'yard. (*Nautical.*) A rope, chain, or tackle

Fig. 2361.



Halving.

for hoisting or lowering *yards*, *spars*, *sails*, or *flags*. The halyards of the lower yards are called *jeers*. *Haulyard; halliard.*

They are named from the spar, etc., to which they are applied; as, —

The *throat* or *peak* halyards of a gaff.

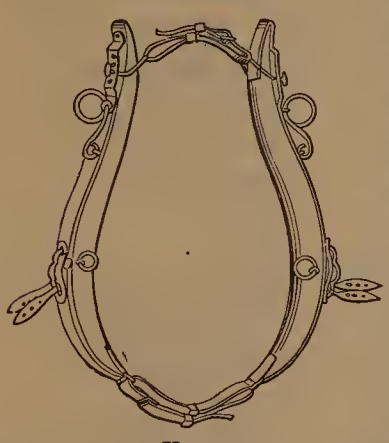
Main-sail, *top-sail* halyards, *driver*-halyards, etc.

Signal-halyards, *pendant*-halyards, *ensign*-halyards.

To haul a yard aloft is to *sway* it; to lower is called *striking*.

Hame. (*Harness.*) One of the pair of curved bars of wood or metal which fit in the crease between the roll and the body of the collar, and to which the traces are connected. The flat wooden hame is still used in heavy gears, secured by thongs (*hame-strings*). The trace-chains are attached to the hooks, and the reins pass through the rings above. The *trace-hooks* of carriage-hames are looped to the staples of the hames.

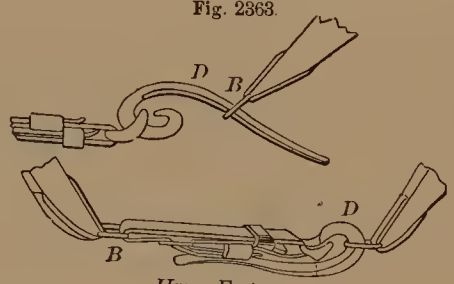
Fig. 2362.



Hames.

Hame-fas'ten-er. (*Harness.*) A device to fasten the ends of hames together, clasping them around the collar. A substitute for a hame-string. In the example, the device is buckled to one hame-loop *B*, and the hook *D* passed through the other loop. The hook is then turned over, as in the lower figure, tightening the hames.

Fig. 2363.



Hame-Fastener.

Hame-lock. A HAME-FASTENER (which see).

Hame-ring. (*Harness.*) With carriage-hames there is one ring on each hame for the driving-reins; with wagon-hames, an additional ring is provided on each for the breast chain or strap.

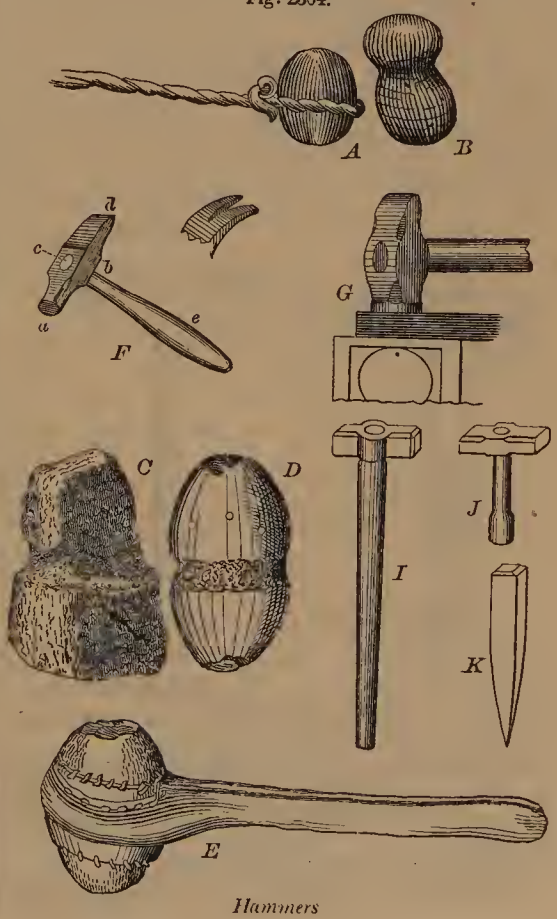
Hame-strap. (*Harness.*) A strap at the upper end of the hames unites them above the collar, and another strap unites them below the collar. The lower is the one which is unfastened to remove the gears.

Ham-knife. In some restaurants, a peculiar long, round-ended carving-knife for shaving off very thin slices of ham or beef.

Ham'mer. 1. A tool for driving nails, beating metals, and the like.

We can hardly admit the statement of Pliny that the hammer was invented by Cinyra, the discoverer of copper-mines in the island of Cyprus. Tools of metal, of which the hammer was among the first, must have been in use for many centuries. Tubal Cain, the descendant in the sixth generation from Cain, was an "artificer in brass and iron"; copper, probably, rather than brass. Brass and bronze are

Fig. 2364.



Hammers

not distinguished from each other, by name, either in Greek or Latin.

The initial form was perhaps a stone fastened to a handle, and used as a club, *A B C D E*. Many such are found in the relics of the stone age, before man had learned the use of metal, the most useful of which, iron, was about the last to be discovered, of those which are applied to the common affairs of life. This stone age is so far in the remote past as to antedate all historical accounts of manners, customs, and appliances. The use of stone, however, in the mode described, still exists among many nations imperfectly provided with a better substitute. In the Bible we read of hammers for nails, forging, and planishing, and for breaking stone.

A B are ancient stone hammers, found in long-neglected workings of the Lake Superior copper region, and are identical with those of other parts of the world. It is not necessary to give them an equal antiquity to the "celts," stone axes and hammers of the stone age of Europe, as many of the implements yet in use among the more barbarous North American Indians are of the same general character. See AXE.

Modern hammers are of many shapes and kinds. The parts are the *handle* and *head*. The latter has an *eye*, *face*, *peen*, or *claw*.

F shows a riveting hammer. Of its parts *a* is the face, *b* the poll, *c* the eye, *d* the peen, *e* the helve.

G is a large hammer used by machinists. Between *F* and *G* is a *claw*, which takes the place of the *peen* of the other hammer. *I* and *J* are miners' hammers; *K* a miner's wedge.

Hammer-making forms a very important part of the industry of the great manufacturing center, Birmingham, and its satellite, Wolverhampton.

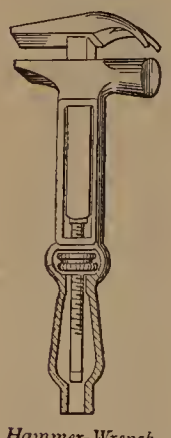
The nomenclature of the various kinds, which are numerous, is generally derived from their application, though in some instances from the form.

File-maker's, *sledge*, *riveting*, *lift*, *raising*, *claw*, *planishing*, *gold-beater's*, *hacking*, *veneering*, may be enumerated among the numerous varieties, as well as *tilt* and *steam hammers*.

Hammers employed in engine work are of three sizes, the *sledge*, *flogging*, and *hand* hammers. See also MINER'S HAMMER.

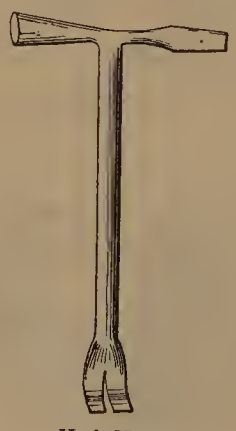
Fig. 2365 is a combined hammer and wrench.

Fig. 2365.



Hammer-Wrench.

Fig. 2366.



Hack-Hammer.

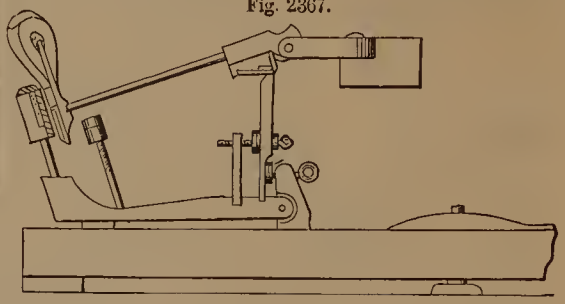
Fig. 2366 is a tack-hammer with claw handle and a sharp peen which forms a screw-driver.

The Japanese hammers are solid cylindrical pieces, not made shapely with waists and graceful outlines like ours. They have the same flat-sided handles as the saws.

2. The *striker* of a clock.

3. (*Fire-arms.*) Formerly, the hammer of the flint-lock was the steel cover of the priming-pan, and the parts connected therewith which received the blow of the flint which was held in the *cock*. With the old flint-lock, the parts of the *hammer* were the *body*, *face*, *back*, *seat*, the *heel* or *tail*, and the *toe*. The hammer of the percussion-lock is the striking part itself, — the *cock*. Such changes are not

Fig. 2367.



Piano-Movement Hammer.

uncommon in mechanics. The piano-jack is another instance. See GUN-LOCK.

4. (*Music.*) A small padded mallet by which the string of a piano is struck.

See also under the following heads: —

About-sledge.
Atmospheric-hammer.
Ball-peen hammer.
Barking-mallet.
Bat.
Beetle.
Bench-hammer.
Bolt-hammer.
Bott-hammer.
Bricklayer's hammer.
Bucking-iron.
Bush-hammer.
Celt.
Chasing-hammer.
Chop-hammer.
Claw-hammer.
Clock-movement hammer.
Closing-hammer.
Commencing-hammer.
Cooper's hammer.
Creasing-hammer.
Dead-stroke hammer.
Dental-hammer.
Drop-hammer.
Enlarging-hammer.
Fid-hammer.
Finishing-hammer.
Flat-hammer.
Flatter-hammer.
Flogging-hammer.
Flue-hammer.
Foot-hammer.
Fore-hammer.
Forge-hammer.
Forging-apparatus.
Friction-hammer.
Furrowing-hammer.
Gavel.
Gold-beater's hammer.
Gun-lock hammer.
Gunpowder-hammer.
Hack.
Hammer-axe.
Hand-hammer.
Hatchet.
Helve.
Holding-up hammer.
Knapping-hammer.
Lathing-hammer.
Lift-hammer.
Machinist's hammer.
Mallet.
Marcus.
Marteline-hammer.
Maul.
Meat-hammer.
Mill-pick.
Millstone-hammer.
Miner's hammer.
Monkey.
Nail-hammer.
Oliver.
Peen.
Percussor.
Piano-movement hammer
Pick-hammer.
Pig-iron breaker.
Planishing-hammer.
Pneumatic-hammer.
Polishing-hammer.
Power-hammer.
Ragging-hammer.
Raising-hammer.
Ram.
Rammer.
Ramrod.
Revolving-hammer.
Riveting-hammer.
Scabbling-hammer.
Set-hammer.
Set-up hammer.
Shingling-hammer.
Shoe-hammer.
Sledge-hammer.
Spalling-hammer.
Spreading-hammer.
Stamp-head.
Steam-hammer.
Stone-breaker's hammer.
Stone-hammer.
Striker.
Swaging-machine.

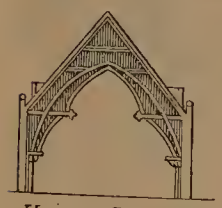
Tack-hammer.
Tilt-hammer.
Trip-hammer.
Venecring-hammer.
Wrench-hammer.

Ham'mer-axe. A double tool having a hammer at one side of the handle and an axe at the other.

Hammer-beam. (*Carpentry.*) A timber tie connecting the two rafters of a pair at a point between the apex and footings. A *collar-beam.*

Ham'mer-beam Roof. (*Carpentry.*) A roof, the feet of the principal rafters of which are not connected by a tie-beam, but usually rest in corbels.

Fig. 2368.



Hammer-Beam Roof.

Half-rafters, carrying a vaulted superstructure, usually partially span the severy.

Ham'mer-cap. A cover for the cock of a gun.

Ham'mer-catch'er. (*Music.*) A padded shoulder which catches the hammer on its return. See PIANO-MOVEMENT.

Ham'mer-cloth. (*Carriage.*) The cloth which covers a coach-box; so called from the old practice of carrying a hammer, nails, etc., in the box of the seat; or from *hamper.*

Ham'mer-hard'en-ing. Beating metal with a hammer while cold, to close the pores and condense the texture.

Ham'mer-helve. The shank of a forge or trip-hammer. On the *helve* is fastened the *hurst* or ring, which has projecting trunnions forming the axis.

Ham'mer-joint. The joint of the pan in the flint-lock.

Ham'mer-mark. A *forge-mark.* A mark of the hammer left from forging.

Ham'mer-nail. The pin securing the cock to the plate of the gun-lock. A *lock-nail.*

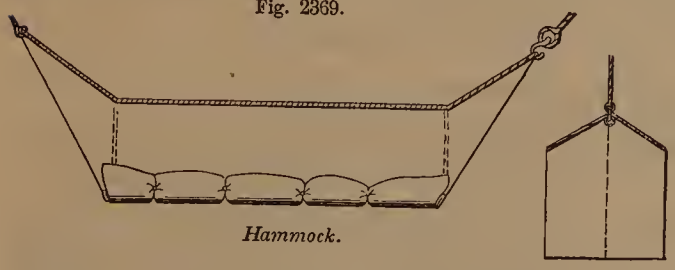
Ham'mer-spring. The spring of the hammer in a gun-lock. Its parts are the *play-side, stud-side,* the *turn,* the *flower,* the *stud,* the *eye;* through the latter passes the rod of the spring-pin.

Ham'mer-tail Spring. (*Horology.*) A long and stiff spring in a clock which gives the effective impulse to the striking hammer, when the latter is retracted for a blow and then released.

Ham'mock. (*Nautical.*) From *hamac;* the suspended bed of the Bahama-Islanders when discovered by Columbus.

A swinging sea-bed, common in South American countries and elsewhere, and made of manilla, sea-

Fig. 2369.



Hammock.

grass, and other fiber, often ornamented and of delicate material. "The undisputed invention of Alcibiades" (ADMIRAL SMYTH). It is a piece of canvas, 6 by 4 feet, the end gathered by *knittles* and a *grommet,* forming the *head* and *foot clews,* to which is attached the lanyard by which it is suspended from rings in the deck beams.

The illustration is rather a swinging cot.

The orders on board ship are, "Down all hammocks!" "Up all hammocks!" "Lash hammocks!" Their respective meanings are, to carry below and sling; to unsling and stow away; to brail up to allow a clear passage between decks.

Ham'mock-net-tings. (*Nautical.*) A row of forked, upright, iron stanchions, supporting a netting or wooden trough, in which the seamen stow their hammocks during the day.

Ham'per. 1. A large wicker-work covered basket, used for packing up liquors, etc., for carriage.

2. A fetter.

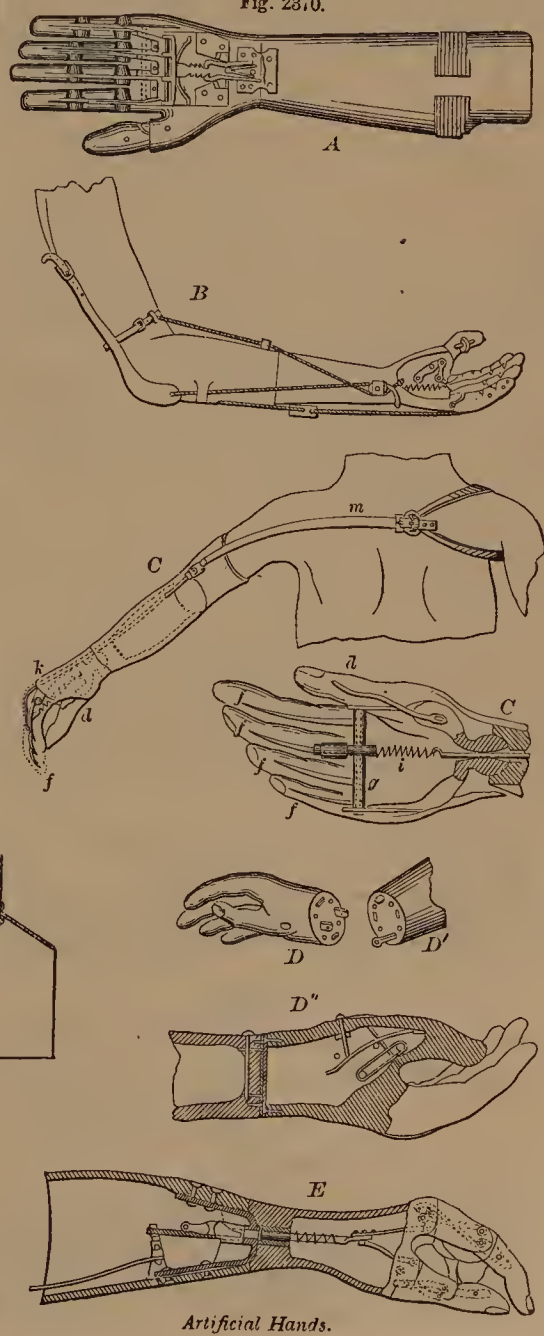
3. (*Nautical.*) Equipment and gear about the decks of a vessel.

Ha'mu-lus. (*Surgical.*) An instrument for extracting the fetus.

Hance. (*Architecture.*) The two lower portions of a four-centered arch; the part between the *haunch* (haunch) and the *springing.* *Haunch.*

Hand. 1. (*Horology.*) The pointer or index-finger of a watch, clock, or counter: *hour, minute, seconds,* as the case may be; or known by the dial

Fig. 2370.



Artificial Hands.

to which it belongs, as in the respective dials of the gas-meter or other dial-register.

2. (*Menage.*) Four inches; horse measure.

3. The small of a gun-stock.

4. A handle or helve.

Hand-an'vil. (*Locksmithing.*) A small movable anvil used by locksmiths. It may be supported by the work-bench or held in one hand. A *stake*.

Hand, Ar'ti-fi'cial. A prosthetic member to be attached to the stump of the forearm, and having fingers and a thumb with some capacity for grasping. The terminal portion of the artificial arm. See ARM, ARTIFICIAL, where the subject is considered at some length. Of mere hands and wrists a few examples may be given.

A is a hand in which the steel ligatures of the fingers are applied to a transverse rod which is connected to a toothed sliding bar; the position of the bar is regulated by two sliding pawls which can be operated by the other hand, and thus the fingers can be retained in any position.

B is for an amputation of the forearm, and has cords which pass from points of attachment on the arm so as to flex or extend the metacarpus and phalanges by the flexor and extensor movements of the stump.

C C are two views of the Selpho arm, in which the spiral spring *i* draws the fingers *f* constantly towards the thumb *d*, and retains any article placed within the hand and between the thumb and the fingers. The artificial hand may be opened by a motion of the opposite shoulder drawing on the shoulder strap *m* and cord *k*, or by extending the artificial hand and arm. *g* is a metallic cross-pipe on which the fingers are constructed.

D D' D'' are views of a hand which is detachable at the wrist. The clasps issuing from the artificial stump have sliding motion to clamp any article placed between their claws. These clasps enter slots in the wrist-plate of the hand. The thumb is adjustable in two positions by means of a spring and catch, the latter being freed by a trigger.

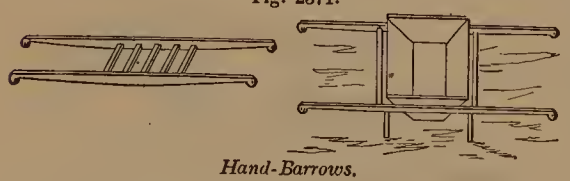
The spring thumb has a latch for holding it open when desired, and means for releasing the thumb from the latch when required.

In *E*, the detachable hand is so fitted to the forearm as to admit of a natural degree of rotary motion at the wrist, and that the hand may be detached by simply unlatching and withdrawing it from the socket without the trouble and delay usually necessary in disuniting the mechanism employed in moving the fingers. In place of the hand a grasping claw, having a swiveling socket, may be attached to the arm at will.

Hand-axe. A light axe which may be used in one hand in the manner of a hatchet.

Hand-bar'row. A device which has a pair of handles at each end, and is adapted to be carried by two men. A *hand-bearer*, *litter*, *bier*, or *stretcher*.

Fig. 2371.



Hand-Barrows.

The difference is in the fitting up. The hand-barrow is intended for a load of packages, goods, or materials, and the illustrations explain its structure.

Hand-bell. A small bell with a handle, used for various purposes. They are sometimes silver-plated or gilt, or even of solid silver. The illustration shows an *altar*-bell for church service.

Fig. 2372.

Hand-Bell.

Hand-bill. A bill-hook. A chopping tool. See BILL-HOOK.

Hand-board. One used in rolling port-fire cases and similar work.

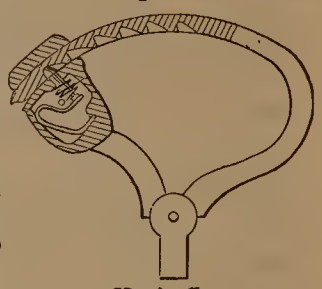
Hand-bor'er. (*Well-boring.*) A *pitching-borer* or *short borer* used at the commencement of a well or shaft.

Hand-brace. A tool for boring, consisting of a cranked spindle, at one end of which a broad head or breast-plate is attached by a swivel; at the other end a socket, into which a drill can be fixed. See BRACE.

Hand-car. A car for laborers or track-repairers, and adapted to travel on a railway, being propelled by hand-cranks.

Hand-cart. A two-wheel vehicle, its body balanced on its axle, adapted to carry loads of parcels or goods, and propelled by hand. The varieties are somewhat numerous, but preserve the general features stated.

Fig. 2373.



Handcuff.

Hand'cuff. Usually in the plural, *handcuffs*. A chain and locking-rings; a strap or other *manacle* for the hands. That in the example may be closed fast by slipping the parts together, but the spring-bolt can only be disengaged by a key.

Hand-cul'ti-va'tor. (*Agriculture.*) One on a small scale, adapted to be drawn or propelled by manual power.

Hand-drill. A drilling-tool for metal, operated by hand, in contradistinction to a drilling-machine.

The cut shows a drill mounted on a bench by means of a clamping vise. *A B* represent two positions of the drill, one arranged for oblique presentation and the other for vertical.

C is a drill in which pressure is applied by the foot, and motion by the hand. *D* is a common hand-drill, with a cast frame. *E F* are side and front elevations of Nasmyth's drill.

There are many other forms of hand-drills, such as ratchet, bow, dental, Persian drills, etc. See list under DRILL.

Hand Feed-pump. (*Nautical.*) A deck feed-pump.

Hand-file. A somewhat generic term, including most forms of files. See FILE.

Hand-gear. (*Steam-engine.*) The handles of the working gear. The parts by which the driver controls the action of the engine; three sets of levers and rods connected to the slide-valve, eccentric-rods, regulator-valves, and feed-pipe cocks, whereby he can *put on* or *shut off* steam to the cylinders, water to the boiler, or place the slide-valves in a *forward* or *backward* position at his pleasure.

Hand-glass. 1. A bell glass or glazed frame, for the protection of plants.

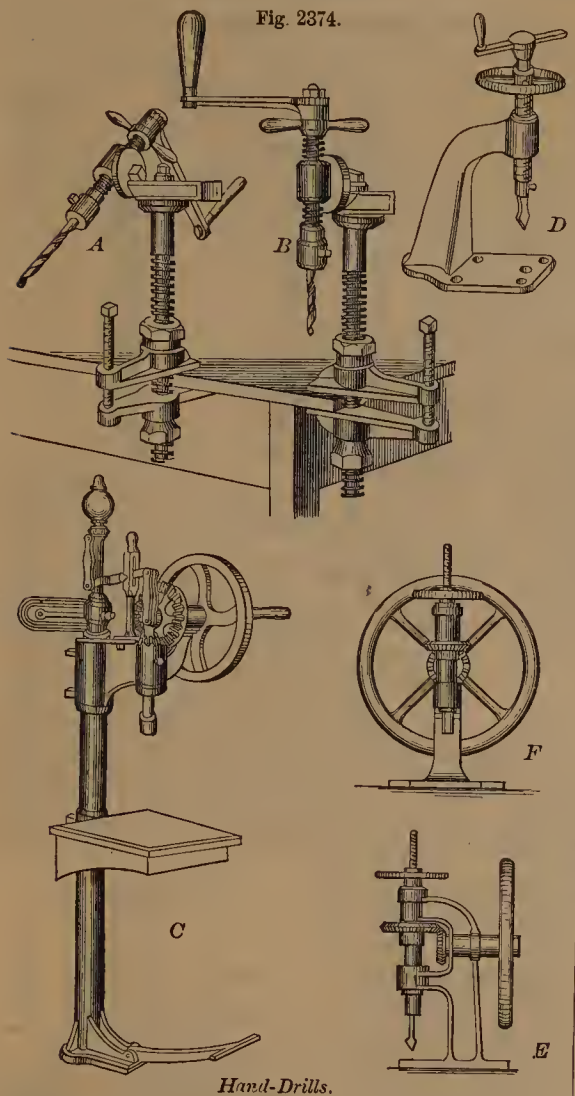
2. A half-minute glass, used as a measurer of time in running out the log-line. See LOG.

3. A small mirror with a handle.

Hand-grap'nel. (*Nautical.*) A small anchor.

Hand-gre-nade'. An explosive projectile of small weight; a shell adapted to be thrown by

Fig. 2374.



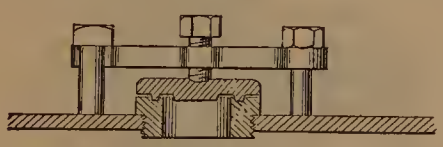
Hand-Drills.

hand, and used of course at near quarters. It is principally used in repelling an attack, being thrown over the parapet at the assaulting party. Also boarding-parties at sea. See GRENADE.

Hand-ham'mer. The machinist's working hammer used in engine and boiler work, in contradistinction to the two-handed *flogging* hammer and the *sledge*.

Hand-hole. (*Steam-boiler.*) A small hole at or near the bottom of a boiler, for the insertion of

Fig. 2375.



Hand Hole and Plate.

the hand in cleaning, etc. It is closed by a *hand-hole* plate, and is smaller than a manhole.

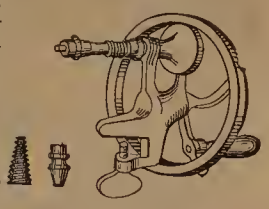
Hand-hook. 1. (*Forging.*) A bent instrument used by smiths in twisting square iron.

2. A hook for handling shells. A *shell-hook*.

Hand-jack. A jack worked by hand or by a lever, pinion and rack, screw, etc. See list under JACK.

Hand-lathe. 1. A small lathe mounted on a bench or table and turned by a hand-crank or by a bow. It is usually portable, and may be secured by a clamp to the bench. It is used by watch and clock makers, dentists, and other workers in small machinery.

Fig. 2376



Hand-Lathe.

2. A *bar-lathe;* one whose puppets slide on a prismatic bar.

Han'dle. A portion of or added to a tool, by which it is grasped. The *hand-hold.*

The *helve* of a hammer or axe.

The *haft* of a knife.

The *hilt* of a sword.

The *stale, staff,* or *stilt* of a plough.

The *stale* of a rake. Qy. from *hale,* to pull or draw.

The *stock* of a drill, bit, or gun.

The *bail* of a kettle.

The *rounce* of a printing-press, by which the form is run in and out, under and away from the platen.

The *shaft* of a boat-hook, spear, lance, or harpoon.

The *hand-lever* of a steam-engine, by which it is started, reversed, etc.

The *knob* of a door, or lock.

The *brake* or *lever* of a pump.

The *crank* of a winch or crab.

The *nib* of a scythe.

The *pommel* of a saddle.

The *trigger* of a gun-lock.

The *helm* or *tiller* of a rudder.

The *dolphin* of a gun. In bronze guns of the old construction handles were usually cast over the center of gravity of the piece, for convenience of handling and slinging. These were formerly made in the shape of a fish, and hence were called *dolphins.*

Handles for case or pocket knives are made of various materials: elephant and walrus ivory; stag, buffalo, and cow horn; tortoise-shell, bone, mother-of-pearl; cocoa, snake, rosewood, etc.

With *case knives* or *table knives* the tang of the blade is secured in the haft by means of cement, transverse rivet, end nut on the through tang, spring catch, or other device. Balance handles are made by introducing lead into the handle to counterbalance the weight of the blade.

With *pocket knives* the sides of ivory, horn, bone, wood, etc., are secured by rivets to the *scales,* as the side-plates of iron or brass are called.

Machines for making handles are of the nature of lathes, planers, etc., according to the material and the shape required. By such means are manufactured in quantity handles for brooms, scythes, shovels, chisels, whips, plows, etc.

Hand-lead. (*Nautical.*) A small lead for sounding; the term is used in contradistinction to *deep-sea lead.*

The hand-lead weighs from 7 to 11 pounds, and is used with 20 fathoms of line. See SOUNDING.

Hand'ler. (*Tanning.*) A pit containing a weak ooze for the early portion of the tanning process.

Pits containing a stronger solution, and used towards the conclusion of the process, are called *bloomers.*

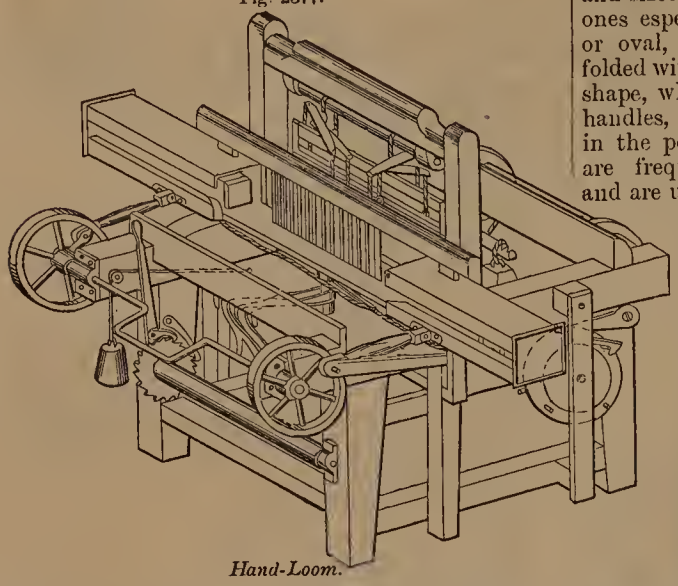
Hand-let'ter. (*Bookbinding.*) A finisher's hand-tool whose face is a single letter.

Hand'ling. (*Leather-manufacture.*) An occasional removal of hides from the vat, allowing them to drain, and then replacing them. The object is to equalize the action of the lime in the process of *unhairing;* of the ooze in tanning, etc.

Hand-loom. A form of loom in which the motions are derived from hand power, either by a crank or by pushing the lathe or batten. In the example,

the driving shaft, at the front end of the machine, is provided at its middle with a crank, so as to enable the weaver to use both hands when required,

Fig. 2377.

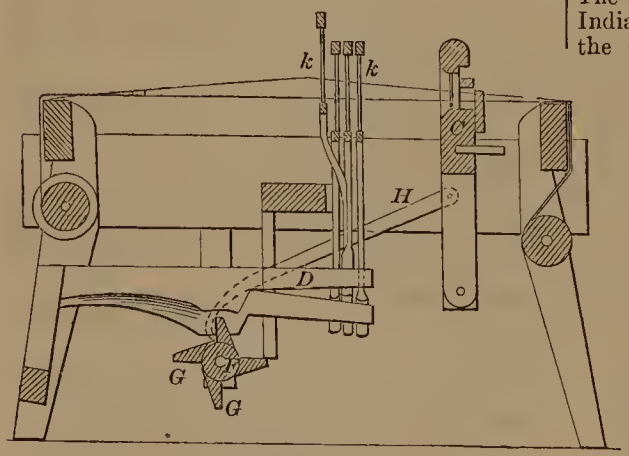


Hand-Loom.

and also to reach any broken thread in the warp. A feed pawl attached to a fly-wheel on the driving shaft operates a ratchet-wheel on a rearward shaft, provided with tappets which depress in succession the treadles. The picker staff projects from a shaft journaled vertically to the batten, and on this shaft is a strap, the ends of which are divided and secured to the alternate treadles. Thus the harness, let-off, take-up, and shuttle motions are all derived from the crank which is by the breast of the weaver.

Fig. 2378 is an example of the other kind, in

Fig. 2378.



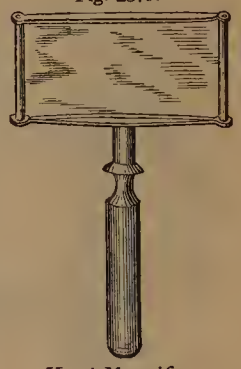
Hand-Loom.

which the motions are all derived from the batten *C*, in which is the shuttle-race. The harness levers *D* are actuated by means of a hooked arm *H* engaging cams *G G* on a shaft *F*. The upright rods *k k* carrying the harness are interchangeable on the treadles, in order to vary the twill or style of the cloth. See LOOM, p. 1354.

Hand-made. (*Paper.*) Said of paper made with a wire-cloth and deckel, by slipping out a quantity of pulp, allowing a partial drainage, and then transferring the mat to the felts.

Hand-mag'ni-fi'er. A lens, usually of doubly convex form, mounted and provided with a handle. They are of various shapes and sizes; some, the smaller ones especially, being round or oval, and adapted to be folded within a case of similar shape, which constitutes the handles, so as to be carried in the pocket. Larger ones are frequently rectangular, and are used as readers. The lens may be of meniscus or concavo-convex form, to adapt it to the sight of the user, having a large field of view, for convenience in reading print or viewing objects which do not require a large magnifying power.

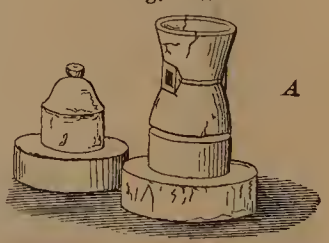
Fig. 2379.



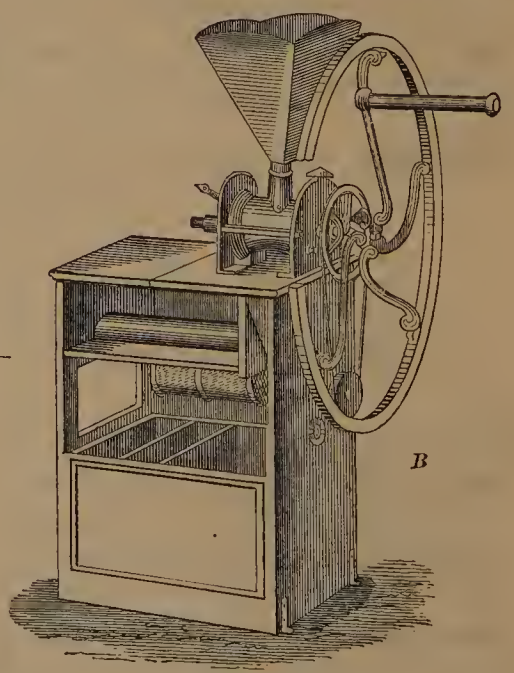
Hand-Magnifier.

Hand-mill. The original mode of making meal was by bruising the grain. This plan was earlier than any form of grinding by a mill. In the time of Pliny one variety of bread was made from pounded grain, and was highly esteemed. (See BREAD.) The references to mills in the Bible all concern the hand-mill, which was universal throughout the Orient, the references to it in old writings, the illustrations of old monuments, and the remains of the machine itself, being very numerous and widely scattered. *A* (Fig. 2380) represents two mills of Pompeii. A golden hand-mill was one of the most honorable presents from a Persian king to a subject.

Fig. 2380.



The Romans found the British in possession of the *quern*. The North American Indians adhered to the *mortar*, and the



Hand-Mills.

hollowed stones yet mark the sites of their villages in those parts where corn was cultivated. The Mexicans use a spindle-shaped rub-stone in a hollow bed-stone.

The almost universal form of hand-mill was two circular stones, the lower was the bed-stone and stationary, and had a central pivot for the upper one, which had an eye. The upper stone was turned by means of a vertical handle. See GRINDING-MILL.

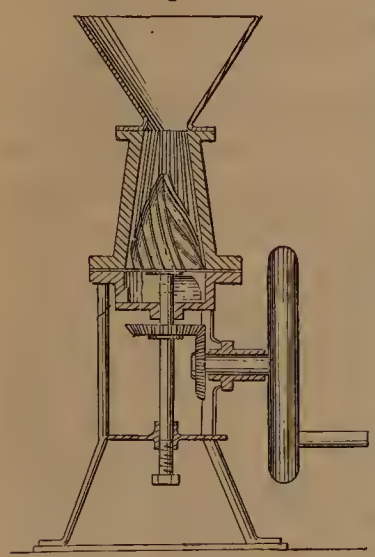
The mill adopted by Napoleon, and used by him in his invasion of Russia in 1812, consisted of two circular cast-iron plates, about 12 inches in diameter, placed in a vertical position. One was fixed, the other rotated by a hand-crank. The plates were indented all over with radiating grooves, and the corn was conducted to the center, or eye, by a lateral hopper. The meal, as it was ground, was projected from the periphery by the centrifugal force of the revolving plate.

Hebert's hand-mill (English) is adapted to grind and dress; an annular surface of fine wire gauze surrounding the bed-stone receives the meal as it issues from beneath the stone. Brushes on the skirt of the runner pass continually over the wire gauze and drive the flour through the interstices, while the offal is swept to an opening and carried by a chute to a separating sieve, which sorts it into grades.

The mill *B* has a conical grinder, and the meal falls into a rotating sieve which sorts it into flour, shorts, and bran. The fly-wheel is shown partly broken away to expose the parts more fully. See GRINDING-MILL; COFFEE-MILL.

Fig. 2381 is a hand-mill in which a conoidal metallic buhr works on a vertical axis in a conical serrated shell.

Fig. 2381



Metallic Buhr-Mill.

Hand-mold. The mold in which hand-made type is cast. It has a lip to receive the metal which runs into the mold containing the matrix. The mold is then opened and the type drops out.

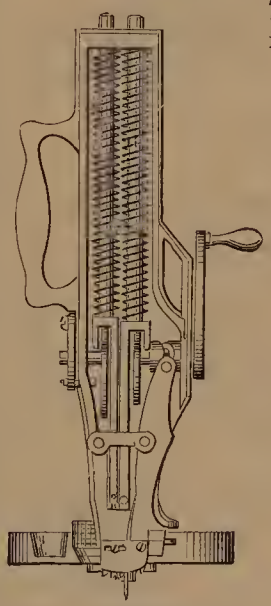
Hand-or'gan. An organ arranged to play automatically from a rotatory motion; its parts consisting of the pipes, arranged vertically in the front, the barrel, placed at the top and back, the keys, vertical between the two, the bellows under the barrel, and the *grinding* and *shifting* gear at the side. The barrel extends the length of the hand-organ, and is about four or five inches in diameter. This has little brass staples of a length corresponding to that of the note, and which, when the barrel revolves, open the pipe valves. They project about an eighth of an inch above the cylinder, and for each tune are allowed one sixteenth of an inch along the length of the barrel to every key, the latter being placed at a distance apart corresponding to the number of tunes. One revolution invariably plays the whole tune, and longer tunes have to be cut down to this, except for regular operatic organs, where an automatic shifting apparatus is used. Otherwise the barrel is shifted by gear at the side under control of the grinder, which makes a difference of one sixteenth one way or the other along the barrel. The pipes are made from hard wood, as boxwood, or from reeds. The blast for them is furnished by the bellows, which is worked by gear from the crank, like the barrel. The keys resemble those ordinarily used in musical instruments. The most important part of the manufacture consists in arranging the position of the points or staples of the barrel. An ordinary piece of sheet music is before the workman, and the barrel of a hand-organ is mounted below it so as to revolve with a large wheel at his left hand. This wheel is divided up into parts which correspond to the bars in music. Above the barrel are a set of keys, with little teeth that indent the paper wound around the barrel. He sits down before the instrument, revolves the wheel one bar, and strikes with a hammer the proper keys, then revolves again, and so on. The indentations mark the places for the brass points and staples, which another man inserts.

Hand-peg'ger. A portable pegging-machine, operated by hand and fed around the shoe, the operator holding the machine in a vertical position and turning a crank which sets all its working parts in motion.

The illustration shows a machine which is held upon the sole of the boot or shoe by one hand of the operator, who turns the crank with the other. The awl is first driven through the sole, and as it rises the machine feeds itself along the distance between the pegs, which brings the peg end of the strip over the hole just punched; the peg is then cut off and driven down by the plunger which holds it, and the end trimmed off by the machine.

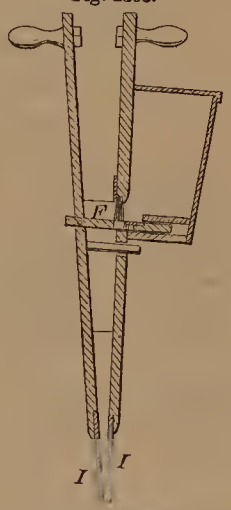
Hand-plant'er. A corn-planter carried in the hands, or by one hand, and thrust into the ground like a stick.

Fig. 2382.



Hand-Pegger.

Fig. 2383.



Hand-Planter.

The thrust and lift usually work the seed-slide, but in some two-handed planters, as in the example, the thrusting together of the portions opens the plates *I I* and allows the seed to drop into the ground. Pulling the handles apart works the slide *F*, and draws seed from the box ready for the next hill. See CORN-PLANTER.

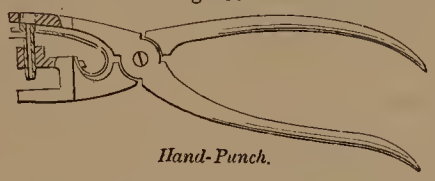
Hand-pump. 1. (*Steam-engine.*) A pump placed alongside the fire-box of a locomotive and

worked by a hand-lever, to feed the boiler when the engine has to stand with steam up. The Giffard injector obviates the necessity for a hand-pump, as it is always operative when steam is up. Hand-pumps are also arranged for other engines. Small auxiliary boiler-feeding engines are used for the Western rivers.

2. An ordinary small pump for domestic and other uses; as distinguished from a power pump. See list under PUMP.

Hand-punch. A punch for perforating tickets, leather, or paper, for the insertion of eyelets or for

Fig. 2384.



Hand-Punch.

other purposes. It has a cutting tube and an anvil, or a punch and hollow die. The conductor's punch is a familiar instance.

Hand-rail. 1. The horizontal rail of a balcony, a baluster, on a stairs, or along the sides of a locomotive engine, to protect the engineer in going forward and back on the engine.

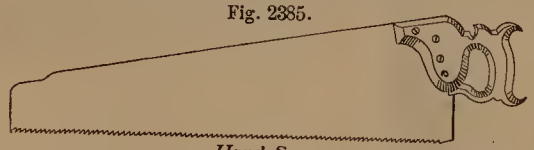
2. Also on the companion and quarter-deck ladders, on the break of the poop, quarter-deck, or forecastle, permanent gangway ladders, etc.

Hand-rail Plane. A round-soled plane for dressing the upper surface of a baluster rail. A *capping* plane.

Hand-saw. A saw riveted at one end to the handle, and adapted to be driven by one hand.

There are several grades and some variations.

Fig. 2385.



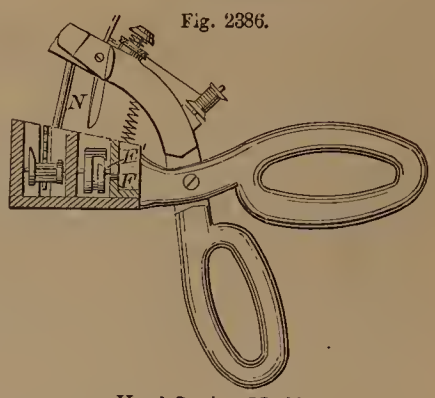
Hand-Saw.

NAMES.	Length in Inches.	Breadth in Inches.		Thickness in Inch's.	Teeth to the Inch.
		At Handle.	At End.		
Without Backs.					
Rip saw	28 - 30	7 - 9	3 - 4	0.05	3½
Half-rip saw	26 - 28	6 - 8	3 - 3½	0 042	4
Hand-saw	22 - 24	5 - 7½	2½ - 3	0.042	5
Broken-space saw	22 - 24	5 - 7½	2½ - 3	0.042	6
Panel-saw	20 - 24	4½ - 7½	2 - 2½	0.042	7
Fine panel-saw	20 - 24	4 - 6	2 - 2½	0.035	8
Chest-saw	10 - 20	2½ - 3½	1½ - 2	0 032	6 - 12
With Backs.					
Tenon-saw	16 - 20	3½ - 4½		0.032	10
Sash-saw	14 - 16	2½ - 3½		0 028	11
Carcass-saw	10 - 14	2 - 3		0.025	12
Dovetail-saw	6 - 10	1½ - 2		0.022	14 - 18

Hand-screw. A jack-screw used for raising heavy weights. See SCREW-JACK.

Hand Sew'ing-ma-chine'. A form of sewing-machine in which the parts are pivoted jaws, operated in the manner of scissors. The machine illustrated employs two threads to form a lock-stitch. The looping-hook *E'* makes a reciprocating instead of a continuous revolution around the disk bobbin *F*. The bobbin and looping-hook are contained in one part, and the eye-pointed needle *N* is attached to the other portion. There are other forms.

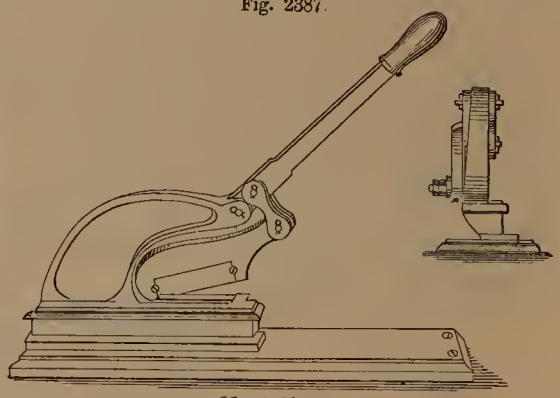
Fig. 2386.



Hand Sewing-Machine.

Hand-shears. (*Metal-working.*) *a.* A machine for cutting metallic plates, having a reciprocating

Fig. 2387.



Hand-Shears.

knife, cutting shearwise, and moved by a hand-lever. The illustration shows side and end elevations.

b. Snips. Shears used by hand in cutting sheet-metal.

Hand-shut'tle. (*Weaving.*) The common shuttle as distinguished from the *fly-shuttle.*

Hand'spike. A loose bar forming a lever for lifting or shifting an object.

In the United States ordnance department, handspikes are commonly made of three sizes, viz.: trail handspikes for field service, maneuvering handspikes for siege and garrison purposes, and handspikes for mechanical maneuvers. The two former are 66, and the latter 84 inches in length. *Shod* handspikes — that is, handspikes having an iron plate under their lower end — and *roller* handspikes are also employed for certain purposes. A *heaver.*

Handspikes are used in working windlasses; those for capstans are known as *bars.*

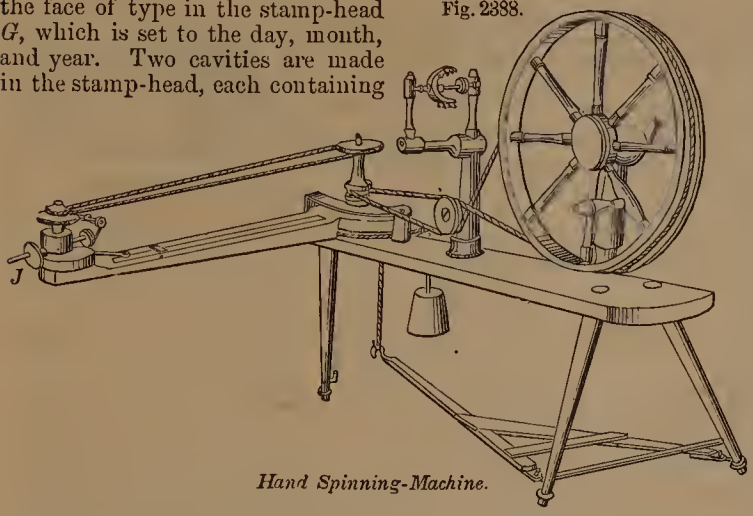
Hand'spike-ring. (*Artillery.*) The thimble on the trail transom of the gun, for the handspike by which it is maneuvered.

Hand Spin'ning-ma-chine'. A form of spinning-machine in which a carding is fed by hand to the spindle, which is revolved by a cord from a large wheel, driven by the hand in the intervals of piecing on new lengths of carding. The usual form of rustic spinning-machine is familiar, but the example is intended to allow a person to sit and spin, the spindle *J* being carried away from the person by pressure on the treadle instead of the person walking backward from the spindle to draw out the carding.

Hand-stamp. One for canceling, dating, or addressing papers, envelopes, documents, etc. The example has a colored ribbon, which is drawn over

the face of type in the stamp-head *G*, which is set to the day, month, and year. Two cavities are made in the stamp-head, each containing

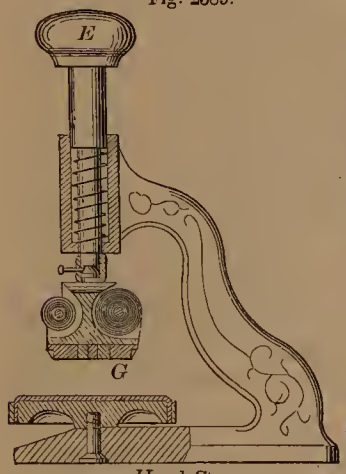
Fig. 2388.



Hand Spinning-Machine.

a reel. One reel contains the inked ribbon, which is led under the head over the type, and is rolled up on the other reel. This head is secured to its stem by two screws, one catching in a nick in one side of the plate, and the other in a

Fig. 2389.



Hand-Stamp.

Fig 2390.

Hand-Truck.

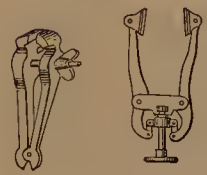
segmental slot on the opposite side. The head is depressed by a blow on the head *E* of the spring plunger.

Hand-swipe. A water-raising device. The *well-sweep* or well-pole of the West; the shadûf of Egypt and Syria. See SHADUF.

Hand-truck. A small truck used in mills, shops, and warehouses.

Hand-vise. A small vise for holding an article while it is being filed, shaped, bored, heated, or otherwise. A common form is a vise with a tang, in some cases driven into a handle. The jaws are operated by a thumb-screw. It is also known as a tail-vise.

Fig. 2391.



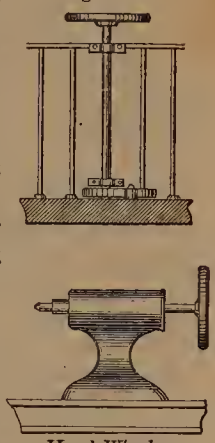
Hand-Vises.

The figure on the right is a hand-vise or clamp whose jaws are swiveled to the arms and are opened or closed by the traversing nut and connecting links; the cheeks of the jaws may be presented outward or inward.

When of peculiar forms, these implements have names indicative of their shape; as, *dog-nose*, *pig-nose hand-vise*, *cross-chap* vise.

Hand-wheel. The term is applied to wheels which are turned by hand to actuate machinery, to set it in motion or to stop it. As the wheel on the brake-shaft of a railroad car; on the tail center of a lathe; on the stem of a throttle-valve, etc. The applications are very numerous.

Fig. 2392.

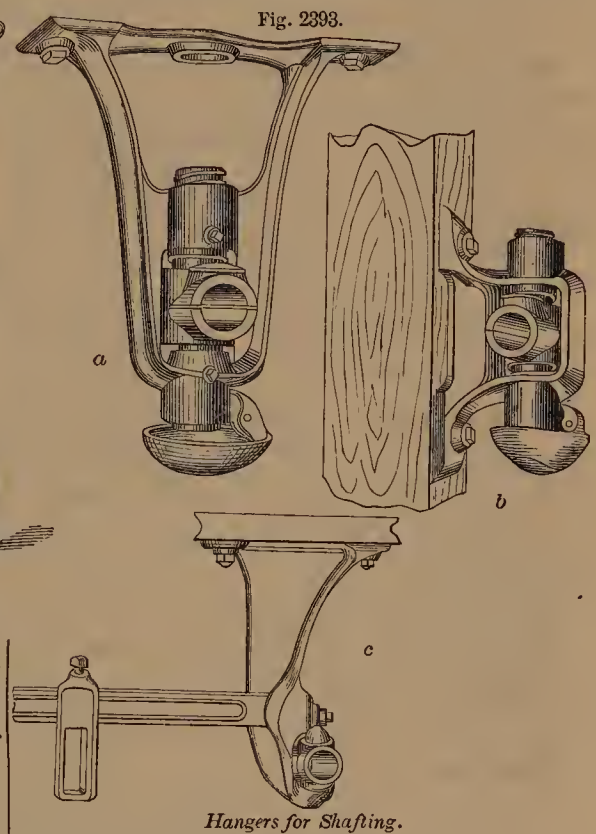


Hand-Wheels.

Hand-wheel Lathe. A small-bench lathe in which the spindle in the head-stock is turned by hand.

Hang. (*Shipbuilding.*) The curvature, concave on the downward edge, of a plank or strake when bent to the frames of a ship. A curve in the reverse direction is called *sny*.

Fig. 2393.



Hangers for Shafting.

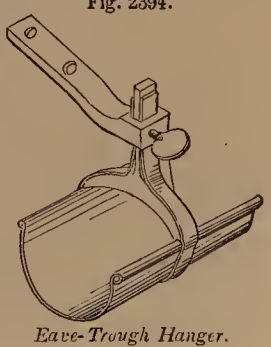
Hang'er. 1. A means for supporting shafting of machinery. The illustrations show several kinds.

a is a ball and socket hanger adapted to be attached to a joist or beam of the ceiling of a machine-shop.

b is a hanger attached to a post.

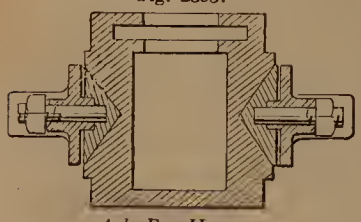
c is a countershaft

Fig. 2394.



Eave-Trough Hanger.

Fig. 2395.



Axle-Box Hanger.

hanger; has a ball and socket joint, and a belt-shifter arm.

2. A pedestal or frame dependent from the car or truck body, and in which the axle-box moves up and down as the springs contract and expand. (Fig. 2393.)

3. A means of suspending an object, as of spouting at the eave of a house (Fig. 2394), a cage, a basket, or what not. An overhanging bracket.

4. A seaman's cutlass; a short curved sword.

5. (*Weaving.*) The lower part of the heddle, or the lower heddle of the harness of a fancy loom.

Hang'ing-bridge. 1. (*Steam.*) A hollow, vertical partition depending from the bottom of a boiler and serving to deflect the flame. The *hollow* forms a part of the water-space of the boiler. The usual water-bridge rises from the furnace floor at the rear of the grate space.

2. *a.* A suspension bridge.

b. A truss-frame bridge.

Hang'ing-but'tress. (*Masonry.*) A buttress supported on a corbel.

Hang'ing-com'pass. (*Nautical.*) A suspended overhead compass in a cabin, viewed from below; known as a *tell-tale.*

Hang'ing-knee. (*Shipbuilding.*) One fayed vertically to the side, under the *deck-beam* knees, or *lodging* knees, which are horizontal.

A *hanging standard* knee is one directly beneath the beam, and fayed to it and to the side.

Hang'ing-ma-chine'. (*Bleaching.*) A machine on which cloth is hung to dry. It usually has tenter hooks for stretching the cloth by its edges. See HOOK-FRAME.

Hang'ing-post. (*Carpentry.*) That to which a door or gate is hinged. The other is the *shutting* post.

The *hanging stile* of a door is that one whose vertical edge has the hinges.

Hang'ings. Wall coverings, such as arras, tapestry, or paper.

Hang'ing-side. (*Mining.*) The overhanging side of an inclined or *hading* vein.

Hang'ing-stile. (*Joinery.*) That stile of a door to which the hinges are attached.

Hang'ing-tie. (*Architecture.*) A tie which is supported by strap and collar, dependent from the rafters above.

Hang'ing-tool. (*Iron-turning.*) A crooked tool, which partially embraces the rest so as not to be easily displaced. The cutter is formed with hollow faces to facilitate grinding. It is used for smoothing the surfaces of iron ordnance, rollers, and similar objects.

Fig 2396.

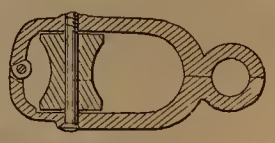
Hanging-Tool.

Hang'ing-valve. A hinged and gravitating valve in a rotary pump or engine, which falls down and forms an abutment, but is lifted by the passing piston so as to close an opening in the annular chamber while the piston is passing. A *clack*-valve. A *flap*-valve. See list under VALVE.

Hank. 1. (*Nautical.*) One of the *hoops* or rings of ash or iron to which the *weather-leech* of a *fore-and-aft* sail is *bent*, and by which it slides on the mast or stay, in hoisting by the *halyards* or lowering by the *downhaul.*

Sometimes the *head* of a *spanker* or *try-sail* is bent to *hanks* which slip on the *gaff.*

Fig. 2397.



Sail-Hank.

2. (*Yarn.*) *a.* Two or more skeins of yarn, silk, wool, or cotton, tied together.

A *hank* of *cotton* yarn is 840 yards in length, and consists of 7 *lays* of 120 yards each.

It is wound on a reel 4½ feet in circumference, 80 revolutions of which make a *lay.*

The *hanks* of cotton yarn are rated by the number which it takes to make a pound.

Throstle-spinning is seldom employed for yarns above Nos. 40 to 50, but with *mule*-spinning very high numbers have been reached. Previous to the introduction of the mule, few spinners could make yarn over No. 200. The natives of India, however, in their patient way and humid climate, made Nos. 300 to 400. Houldsworth, of Manchester, England, has made No. 700, which was woven in France. He is stated to have reached No. 10,000, a fineness beyond all useful range, but interesting as illustrating the perfection and capacity of his machinery.

b. A measure of 3,000 yards of *linen* yarn.

Table.

300 yards = 1 lea.
10 leas, 3,000 yards = 1 hank.
20 hanks, 60,000 yards = 1 bundle.

Han'som. (*Vehicle.*) A kind of cab, named after the inventor, in which the driver's perch is behind the cover of the occupant's seat, the reins passing above the hooded top.

Har'bor. 1. (*Hydraulic Engineering.*) A shelter for ships, where they may moor or ride at anchor.

2. (*Glass-making.*) A chest, 6 or 7 feet long, in which the ingredients for a charge are mixed and held.

Hard. 1. (*Hydraulic Engineering.*) A hard bottom of gravel laid across a swamp or at a muddy boat-landing.

2. The coarse part of flax. *Hurds.*

Hard'en-ing. 1. (*Metal-working.*) The process of giving an additional hardness to metallic articles after leaving the hands of the workman shaper.

Hammering and rolling will confer hardness, and in the reduction and shaping of articles by these means it becomes necessary to alternate annealing with the condensing processes.

The hardening of steel is accomplished by heating it to a certain temperature and then suddenly quenching it in water or oil. When the article is not required to be at its ultimate hardness it is *tempered* by *letting down* the temper. This is done by heating the article, observing the change of color. See TEMPERING.

Copper alloys for gongs are hardened by another process, in some respects the reverse of that adopted for steel. See ANNEALING.

Iron is surface hardened by heating to a bright red, sprinkling with prussiate of potash, allowing to cool to a dull red, and cooling with water. Two recipes: —

Prussiate of potash . . .	3	1
Sal-ammoniac	1	2
Bone-dust		2

Or heat pieces of horn, hoof, bone-dust, or shreds of leather, together with the article to be case-hardened, in an iron box, bring to a blood-red heat, then

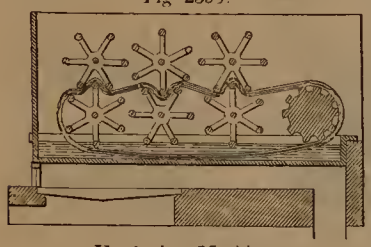
immerse the article in cold water. Some cut up the shreds, etc., fine, and mix them with white wine, vinegar, and salt.

2. (*Hat-making.*) The process of pressing together the light layer of filaments collected in the *basket*, so as to form it into a sheet of *felt* with sufficient cohesion to bear handling. The hands and then a *skin* are employed to produce this effect, the pressure, rubbing, and jerking causing the filaments to interlace and become felted, the body gaining consistence and hardness at the expense of its bulk and area.

3. A process of heating in the course of porcelain making. See HARDENING-KILN.

Hard'en-ing-fur'nace. (*Hat-making.*) A furnace with an upper plate of iron, upon which hat-bodies, folded in wet cloths, are laid to be hardened by heat, moisture, and the pressure of traversing plates above.

Fig 2398.



Hardening-Machine.

In the example, the fabric with its inclosing envelope is attached to the endless band, and carried alternately through the pan of hot liquid and between the star-shaped rollers, which causes the fur to work into the felted body of the hat and firmly adhere. The furnace has a descending flue for convenience in conveying away the smoke. The liquid in the pan may be a solution of sulphuric acid and water. The star-shaped rollers are moved by suitable gearing outside the tank.

Hard'en-ing-kiln. (*Porcelain.*) A kiln in which printed biscuit is placed in order to drive off the oil of the color previous to glazing. See PRESS-PRINTING.

Hard'en-ing-skin. (*Hat-making.*) A piece of half-tanned leather laid above a *bat* of felting hair while the latter is compressed by the hands of the workman.

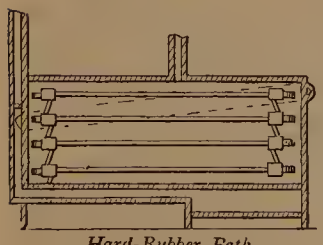
Hard-fin'ish. (*Plastering.*) Fine stuff applied with a trowel to the depth of about one eighth of an inch.

Hard Por'ce-lain. A ware composed of a natural clay containing silex (*kaolin*), and a compound of silica and lime, i. e. a quartzose felspar (*petuntze*). The glaze is also earthy, not metallic.

Hard Rub'ber. India-rubber mixed with a large proportion of sulphur, and subjected to an extreme heat. Other mineral substances, as white-lead, are also generally added. See CAOUTCHOUC; EBONITE.

In Mullee's process, the rubber, after washing, is rolled into sheets $\frac{1}{16}$ of an inch thick, and immediately placed in the sulphur-bath vessel in a horizontal position. The sulphur is kept at a temperature of 220° F. until foam has ceased to rise. At the expiration of the first hour, the heat is raised to from 30 to 40 pounds' pressure, and continued for a second hour, after which it may be allowed to rise to 80 pounds. The whole process takes from 5 to 10 hours. The sulphur used is known as "pure sulphur." Twenty or thirty minutes is sufficient for one immersion, after which the sheets are torn apart, rekneaded, and rolled into sheets. See VULCANITE.

Fig. 2399.



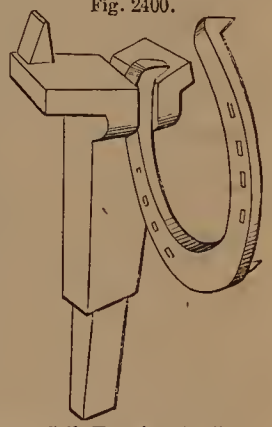
Hard-Rubber Bath.

Hard Sol'der. The solder used for uniting the more infusible metals. Spelter solder and silver solder are the two principal varieties. The former, for copper and iron, is sometimes made in the proportion of 16 parts copper to 12 zinc; more frequently equal proportions of the two metals are employed. These are cast in a grated mold, forming squares of about two pounds' weight, which are then heated nearly to redness and granulated by beating on an anvil or in a mortar. The components of silver solder vary from 4 parts silver and 1 copper for the hardest, to 2 silver and 1 brass wire. Three fourths of a part of arsenic is sometimes added to render it more fusible and impart whiteness. See ALLOY; BRAZING.

Hard'ware. A term including articles of metal for sale, such as house trimmings and furnishings, and mechanic's tools. Sometimes distinguished as *builders' hardware*, *domestic hardware*, and *tools*.

Har'dy. (*Forging.*) A *chisel* or *fuller* having a square shank for insertion into a square hole in an anvil called a *hardy-hole*.

Fig. 2400.



Calk-Forming Anvil.

The hardy-hole is sometimes occupied by a smaller anvil, fullering-tool, or calking-swage, as in the illustration, in which in a steel-faced plate is sunk a vertical groove, and the faces on each side of the groove are inclined, so as to give the proper taper to the inner sides of the calk when the horseshoe is placed within the groove.

Hare. The fibrous portion of flax and hemp, as distinguished from the *shives* or scales of bark, etc., which fall from the hare in braking.

Harl. The filament of flax. *Hare.*

Har-mon'i-ca. (*Music.*) 1. *a.* A musical instrument formed of a number of glasses which are tuned by filling them more or less with water, and are played by touching them with the dampened finger. The less the quantity of water the lower is the tone of the scale. Called *musical glasses*. The instrument is said to have been invented by a German, and was improved by Dr. Benjamin Franklin. A stringed form is ascribed to Stein, 1788.

b. Dr. Franklin's "Harmonica" consisted of a nest of hemispherical glasses, of different sizes, tuned, and arranged on a revolving spindle impelled by a treadle, the tips of the fingers being applied to the edges of the glasses to produce the tones.

Each glass has an open neck or socket in the middle. The thickness of the glass is about $\frac{1}{10}$ inch near the brim, but thicker nearer the aperture, which in the largest glasses is 1 inch deep, with an aperture $1\frac{1}{2}$ inch wide. These dimensions lessen as the glasses diminish in size, the neck of the smallest being $\frac{1}{2}$ inch thick. The largest glass is 9 inches in diameter, and the smallest 3 inches. Between these are 23 different glasses, differing from each other $\frac{1}{4}$ inch in diameter. Each glass is marked with a diamond the note for which it is intended, and is tuned by diminishing the thickness of those that are too sharp. This is done by grinding them round the neck towards the brim, the breadth of 2 or 3 inches, as may be required, frequently testing them by a well-tuned instrument. The largest glass in the in-

strument is C, a little below the ordinary compass of the human voice, and the highest is two octaves above. The glasses of the full notes are painted the seven prismatic colors, and the semitones white.

The glasses are fixed on a spindle of hard iron, 1 inch in diameter at the larger end and tapering to ¼ inch at the smallest, and each glass has a bushing of cork where it is attached to the spindle. The glasses set within each other, a space intervening between the necks of the several glasses. The spindle is mounted horizontally in a box, its ends work in brass gudgeons, and it is impelled by a treadle and band. An inch of the brim of each glass is exposed to be touched by the finger as the spindle and glasses revolve.

The instrument is played upon by a person sitting before the instrument, turning the treadle with the foot, and wetting the fingers now and then with a sponge and clean water.

The fingers should be first soaked in water, and should be perfectly free from grease. A little fine chalk may be added to the water, and will assist in producing the tremulous action of the glasses which causes the tone. Both hands may be used.

2. A small instrument of music held in the hand and blown by the breath. At the edge are a series of holes which conduct the breath to free reeds, like those of an accordeon. A *mouth-organ*.

Har-mon'i-phon. (*Music.*) A small instrument with a key-board, in which the sounds are produced by small metallic tongues, acted upon by air blown through a flexible tube.

Har-mo'ni-um. (*Music.*) A musical instrument whose tones are produced by the vibration of metallic reeds operated by keys. The bellows are worked by pedals, and the keys are arranged in one or two banks. These instruments are made with a variety of stops, and with swell and tremolo attachments. The instrument is used as an organ of small size in parlors, and in churches in the performance of sacred music.

The melodeon and parlor-organ are of this class.

The *harmonium* is substantially the same as the *seraphine* introduced by Green, and has been blessed with a variety of names derived from the Greek and other sources. Among them are *œolophon*, *œolomusicon*, *physharmonica*, *melodeon*, *symphonium*, and *poikilorgue*.

The *free* tongues of the harmonium, though used from time immemorial by the Chinese, were introduced into Europe by M. Grenié in 1810.

Har'mo-nom'e-ter. An instrument for ascertaining the harmonic relation of sounds. It often consists of a single string with movable bridges.

Har'ness. 1. (*Menage.*) The means whereby a draft animal is attached to a vehicle.

The invention is ascribed to Erichthonius of Athens, who was made a constellation after his death, under the name of Boötes, about 1487 B. C. War-chariots are believed to be much older than this. The sculptures of the Egyptian conqueror, Osymandyas, who carried his arms as far as Bactria, 2100 B. C., disprove the Greek claim. The use of harness commenced as soon as the horse was tamed to draft. The wagons that Joseph gave to his brethren to fetch his father, 1706 B. C., were probably ox-carts or wagons. The root of the Hebrew word signifies to roll around.

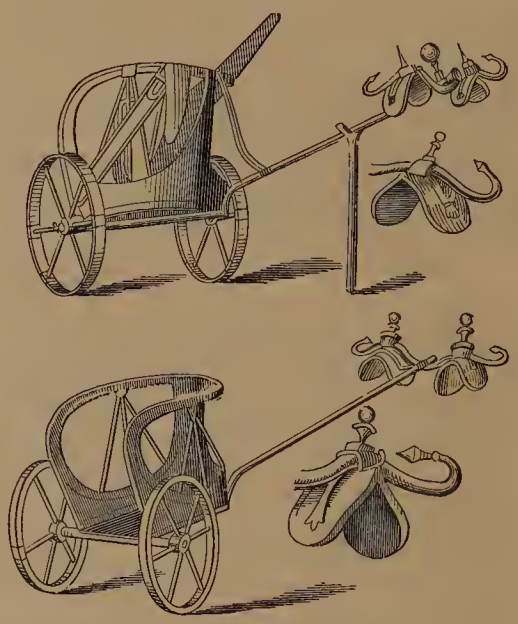
The harness shown in the sculptures of Egypt and Persepolis was of a very simple description. The horses were always hitched abreast to a tongue or pole, which was connected to a yoke. This passed over saddles which rested on the withers of the horses. The accompanying cut shows their relation and position. They were kept in position by straps around the neck and around the girth, and sometimes had a single trace on that side of the horse against the pole.

Solomon had 40,000 stalls for his chariots, 1014 B. C., and plenty of leather harness, no doubt. He bought his horses in Egypt.

While the Egyptian yoked his horses to the pole of his chariot, and gave a third horse a single trace on the side towards the chariot, still more primitive customs were adopted in other lands and at a later date.

In England and Ireland, horses were sometimes hitched to the plows by their tails, a barbarous cus-

Fig. 2401.



Egyptian Car-Saddles (from Wilkinson).

tom that existed in Ireland, as late as 1634, for an act of the Irish Parliament, 11 and 12 Car. II. c. 15, entitled an "Act against plowing by the tayle and pulling wool off living sheep," sets forth, that "Whereas there have been for a long time practiced in this country a barbarous custome of plowing, harrowing, drawing, and working with horses and other animals by the tayle, whereby the breed of animals in the kingdom is much impaired, and great cruelty perpetrated, these practices were henceforward to be considered illegal, and the offender subjected to fine and imprisonment."

"The Spaniards outwitted the French in lining their own harness with chains, so that it could not be cut." — Pepys's *Diary*, 1661. This was on the occasion of a struggle for precedence between the Spanish and French ambassadors in London, September, 1661.

The *single-line* mode of driving horses, usual on farms and with heavy road teams throughout the West, was made very familiar to many during the late war. The government six-mule teams are driven by a man riding the near wheel-horse, and having a single line to a bridle-rein on the near leader. The bit of the off leader is connected by a *jockey-stick* to a hame-ring of the near leader, which keeps him in place. The off-wheeler is governed by the whip, foot, or an occasional touch of his rein; the whip, however, and the word of command, are relied on so far as he is concerned. The near-wheeler, being ridden, is controlled in the usual way; and

the middle span between the leaders and wheelers have no choice but to go with the others and pull when they are told to.

The *single-line* mode of driving is also used by the farmers in the Netherlands, the near horse being guided by the line and the bridles of the middle and off horse (three abreast) being connected to the near horse, "in a manner surprizing to a stranger," says Loudon.

Besides the different kinds of harness depending upon quality and mounting, other varieties are known by the names of buggy, coach, cart, or wagon, according to the vehicle, and the latter have a familiar division into *lead*, *hip-strap*, *breeching*, or *yankee*, according to the construction and arrangement. The latter is perhaps somewhat local, but is as extensive as the West, as we call it.

For a list of the tools and implements of the saddle and harness maker, and the kinds and parts of harness, see SADDLERY AND HARNESS.

For a list of the tools, machines, and various products of the leather manufacture, see LEATHER.

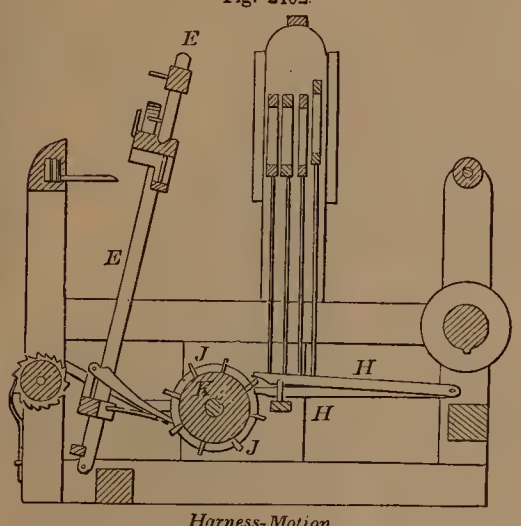
The traces of the wheel-horses in field-carriages are directly attached to the splinter-bar of the limber, no single or double trees being employed. The tongue is supported by neck-yoke and breast-chains. The traces of the leaders are directly attached to the traces of the wheel-horses, and not by means of single trees and spreader chains to the tongue.

2. (*Loom.*) The apparatus in a loom by which the sets of warp-threads are shifted alternately to form the *shed*. Each set of the warp-threads lies in the loops of knotted cords stretched in vertically reciprocating frames called *heddles*, or *healds*. These are moved by cords or straps connected to rods or levers, to which the appropriate recurrent motion is imparted. See LOOM.

The harness of a loom is termed the *mounting*; and the whole apparatus concerned in the motions of the warp-threads is the *shedding*.

The illustration shows a form of hand-loom in which the motion of the lathe *E* is the means of

Fig. 2402.



Harness-Motion.

working the harness in the order required by the twill, check, or pattern. As the lathe *E* is moved toward the treadles *H*, the lever pushes the pin *J*, with which it may be in contact, and revolves the drum *K*, operating the treadles *H*. As the lathe moves forward, the spring raises the lever into position to take hold of the next pin and again revolve the drum at the next backward movement.

Har'ness-bell. A small bell, usually of globular form and carrying a bullet, attached to some part of the harness to produce a jingling sound. A *sleigh-bell*.

Har'ness-board. (*Weaving.*) The *compass-board* of a loom, having holes through which pass the neck twines.

Har'ness-cask. (*Nautical.*) A large cask or tub with a rim cover, containing a supply of salt meat for immediate use.

Har'ness-clamp. (*Saddlery.*) A kind of vise with a pair of jaws closed by a spring, wedge, or screw, and used to hold leather while being stitched.

Har'ness-hook 1. A hook or bracket on which harness is hung.

2. A check-rein hook on the gig-saddle.

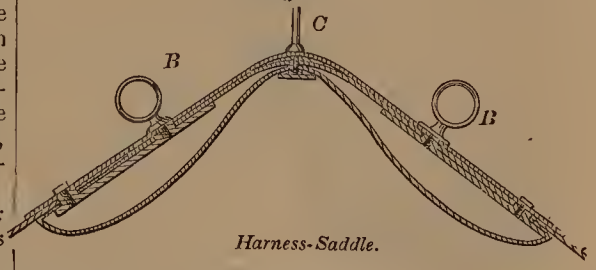
Har'ness-leath'er. A grade and quality of leather from which harness is made. It is blacked on the *grain* side.

Har'ness-pad. A lining or soft wad beneath a saddle to keep the harder portions from galling the back of the animal.

Har'ness-room. One attached to a stable, warmed by a stove, and used for putting away harness.

Har'ness-sad'dle. The part of the harness which rests across the back, and to which the girthing portions are attached. Upon it are the terrets *B B* and check-line hook *C*, and from it proceeds the back-strap, which reaches to the crupper.

Fig. 2403



Harness-Saddle.

Har'ness-snap. A hook for attaching the lines (reins) to the bit-rings; the breast-strap to the hame-rings, etc. A *snap-hook*.

Harp. 1. (*Music.*) An instrument with a three-sided frame, between two of which strings of varying lengths are stretched.

Jubal, the son of Lamech the first (say about 2400 B. C.), was "the father of all such as handle the harp and the organ." His brother Jabal had great stock of cattle, and his half-brother Tubal Cain was "an instructor of every artificer in brass and iron." Quite a distinguished and industrious family. Agriculture, the mechanics, and the fine arts pursued by the sons of one man, a descendant in the fifth generation of Cain.

The harps of Egypt were numerous and various, having from 4 to 14 strings as long ago as the reign of Amosis, about 1570 B. C., 900 years before Terpander. The strings were of catgut, and the form of the frame varied according to its purpose. To be carried or played standing, sitting, or squatting.

One harp discovered in Egypt in 1823 had several remaining strings which responded to a touch, and awoke from a rest of 3,000 years.

a is an Egyptian harp from a painting at Thebes.

b from a painting at Dendera.

c one of the Bruce harpers, two of whom are shown in the original.

One of the harps has 21 strings, the other 12.

These most florid and striking of all the representations of the Egyptian harp are on the tombs of the

Fig. 2404.

Egyptian Harps.

kings at Thebes of the time of Rameses III., 1235 B. C. ; of them Bruce says : "They overturn all the accounts hitherto given of the earliest state of music and musical instruments in the East ; and are altogether, in their form, ornaments, and compass, an incontestable proof, stronger than a thousand Greek quotations, that geometry, drawing, mechanics, and music were at the greatest perfection when this instrument was made, and that the period from which we date the invention of these arts was only the beginning of the era of their restoration."

Pythagoras and his compeers derived their knowledge from this source, and the services of Terpander are probably limited to inventing a method of expressing musical sounds, and perhaps of setting poetry to music. Fame enough for one man.

The Egyptian harps are shown, resting on the ground, supported in front of the person in marching, supported on a stool, and resting on the shoulder ; the latter at Eléythya.

The present scale of musical notation is ascribed to Guido Aretino, a Tuscan monk, about 1025.

"Hermes invented the harp with three strings, causing the three several sounds ; the base, treble, and mean." — DIODORUS SICULUS.

"From the song, the rhythm, and the instruments, all Thracian music is supposed to be Asiatic. The Orphic ceremonies had their origin among this people" (STRABO). The instruments were the cithera, pipes, cotylæ (probably castanets or cymbals) ; embracing wind, stringed, and percussion instruments.

Terpander of Lesbos added three strings to the lyre ; he caused

"New hymns to resound on a seven-stringed cithara."

David is celebrated as a performer upon the harp, and it is said that he was a master of thirty-two other instruments. This was about 1063 B. C.

The *magadis* of the Thracians was a three-cornered harp, with twenty strings arranged in octaves. It was used among them in the time of Xenophon.

A band of 300 harpers was in the great procession of Ptolemy Philadelphus, preceding a column of 2,000 yellow bulls, with gilded horns and frontlets, crowns, necklaces, and breastplates of gold.

Egyptians, Jews, Persians, Thracians, Greeks, Romans, Saxons, Welch, Irish, all had their harps. The number and material of the strings differed, and also the shapes of the frames.

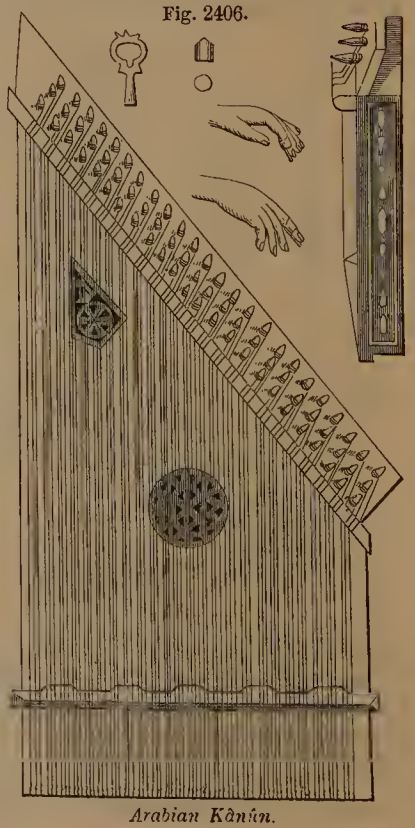
Fig. 2405.

Irish Harp.

The Welsh harp was strung with gut. The Irish harp was strung with wire.

Donagh, the son of Brian Boiroimhe, a king of Ireland who was slain 1014, sought protection at Rome, carrying the harp and regalia of his father, and presented them to Pope John XVIII. in order to obtain absolution for the murder of his brother Teig. Adrian IV. urged this as a title to the kingdom in his bull, transferring it to Henry II. The harp was preserved in the Vatican, and given by Leo X. to Henry VIII. with the title "Defender of the Faith." It is needless to say how much the Pope was disappointed in his pupil. The gold crown of Brian was retained. The harp was given by Henry VIII. to the Earl of Clanricarde, and, after passing through several hands, was lodged in the College Museum, Dublin, 1782.

Fig. 2406.



Arabian Kânûn.

The modern Arabian harp, or Kânûn, is laid flat in the lap while being played. The strings are arranged in groups of three, and the sounding-board is pierced. The strings are stretched as in our pianos, and rest on a bar near the tuning-pins,

and on a bridge-piece above the sounding-board. This harp is played by the fingers, but thimbles with points are used on the two forefingers, forming an approximation to the *plectra* wherewith some of the Egyptian harps and psalteries were struck.

The prostrate harp is the original of a host of instruments played by keys; the early forms were known as the *clavichord*, *virginal*, *spinet*, *clavicymbal*, *clavicytherium*, and *harpsichord*. These grew out of various forms of stringed instruments, known as the *dulcimer*, *psaltery*, *citole lyre*, *cithara*, *cymphonia* or *cymbal*, *cithcrium*, and *harp*. See PIANOFORTE.

The *harpsichord* immediately preceded the *pianoforte*.

In the earlier forms of these instruments the number of strings was not equal to that of the keys, but the latter brought into action devices which shortened the strings, in the manner of a guitar.

We read of an instrument in 1600 which had a key for each string, but this was unusual at that time.

Pedals were introduced 1720; double-action about 1808.

2. A concave grating in a scutching-machine, through which refuse escapes as the cotton is beaten and driven forward by the revolving beater.

3. (*Husbandry.*) A Scotch grain-sieve for removing weed-seeds from grain.

Harp'ing-i'ron. A barbed javelin. The word is derived from its capacity for clawing or grasping. A *harpoon*.

Harp'ings. (*Shipbuilding.*) *a.* The wales of the bow, of extra strength.

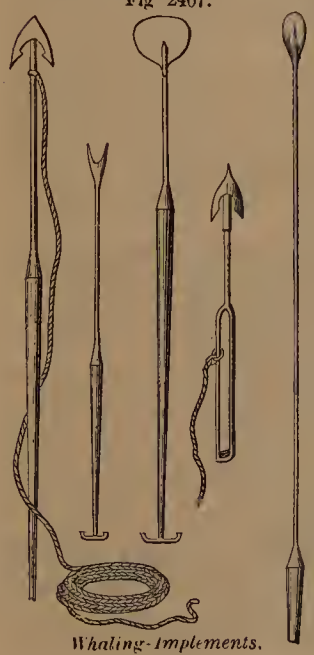
b. A ribband trimmed to the shape of and bolted to the shape of the cant bodies, to hold them together till planked.

c. Cat-harpings; frapping of the shrouds to the masts below the tops.

Har-poon'. A barbed javelin used to pierce and fasten to whales. It has a broad, flat, triangular, barbed, sharp head, and a shank about two feet long, furnishing a socket for the shaft. A line, about 70 fathoms long, is attached to the harpoon, and runs out rapidly as the struck fish dives below the surface.

The harpoon consists of the *point-head* and *shank*.

Fig. 2407.



Whaling-Implements.

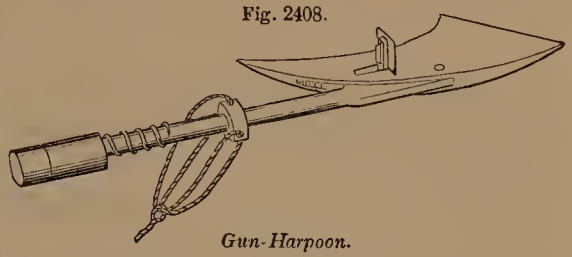
The *fore-ganger* is the section of line which unites it to the whale-line. A whale-line is 130 fathoms, and a boat is provided with several of such. It runs out over the bow, being taken over a *bollard*, which is kept wet.

The word *harpoon* is allied to the *harpago* of the Greeks, which was a grappling-iron, a drag, a flesh-hook. Specimens in bronze of the latter are in the British Museum.

In the accompanying cut are shown the ordinary whaling-implements, the hand-harpoon, pricker, blubber-spade, gun-harpoon, and lance. See BOMB-LANCE; GUN-HARPOON.

Fig. 2408 is a gun-harpoon. The rubber spring on the end of the shaft of the harpoon prevents the recoiling of the gun. A spiral spring around the shaft prevents the line from checking against the butt of the harpoon too sud-

Fig. 2408.



Gun-Harpoon.

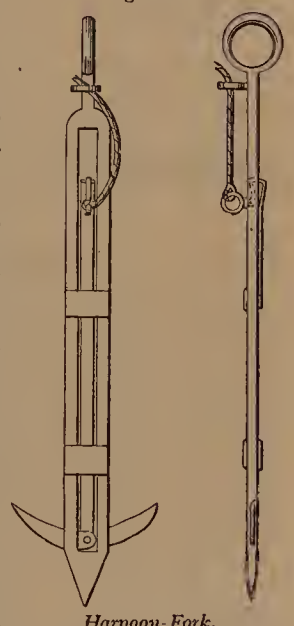
denly. A stop in the pivoted blade secures it parallel to the shaft until released by the stop, being forced down by the entrance of the blade into the whale.

The electric harpoon is fitted with two insulated conductors, connected by wires with a coil-machine kept in the boat. On the harpoon being plunged into the whale's body, electric shocks of a powerful nature are sent until the animal is prostrated.

Another plan proposed is that of firing an explosive shell into the body of the whale from a rifle, by which its vital parts would be destroyed.

Professor Christison has published an account of some experiments made in 1831 for the capture of whales by poison. The agency employed was hydrocyanic or prussic acid, inserted in glass tubes, and in weight about two ounces. A copper wire was attached to each side of the harpoon near the blade, the other end of which passed obliquely over the tube, then through an oblique hole in the shaft, and finally to a bight in the rope, where it was firmly secured. When the harpoon struck the whale, the tubes were crushed. After being struck, the whale dived, but rose in a few minutes quite dead.

Fig 2409.



Harpoon-Fork.

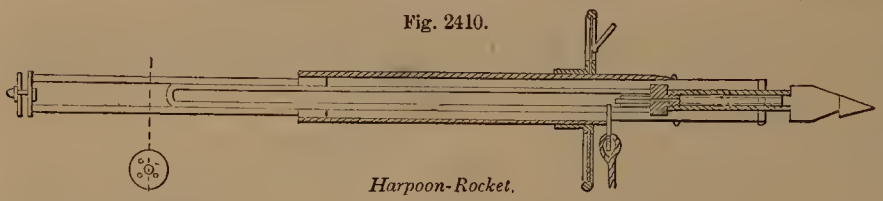
Har-poon'-fork. (*Agriculture.*) A form of hay-fork to be operated by tackle in lifting hay from a load to mow it away, or conversely in loading a wagon from a mow.

The rod being drawn up, the point of the fork is thrust into the hay, which movement depresses the rod and extends the tines, and enables the bent end of the spring to catch the top of the rod; the tines are thus held until the load is raised, when, by drawing on the cord, the spring is pressed back by the bell-crank, and the load discharged. See HAY-FORK.

Har-poon'-rock'et. A bomb-lance for killing whales. That shown has an explosive shell at its head, and is propelled by a rocket-charge after being fired from a gun. The hinged barbs are secured to the breech-piece in the tube, and the line connected by a looped shank.

Harp'si-chord. (*Music.*) An obsolete stringed instrument resembling a harp laid prostrate, the strings being played by quills operated by keys like those of a *piano-forte*.

Fig. 2410.



Harpoon-Rocket.

The harpsichord is believed to have been first made by Hans Rucken, in Germany, about 1510. Used in public festivals in Italy, 1522. Improved by Vincentino, 1555. Vertical form invented by Rigoli of Florence, 1620.

Pepys, in his Diary (1661), speaks of the "harpsichon" at Captain Allen's house, where he saw his dear "Mrs. Rebecca."

The *spinet* was a similar instrument with one wire for each note, and, like the harpsichord, was played with quills on jacks, operated by keys.

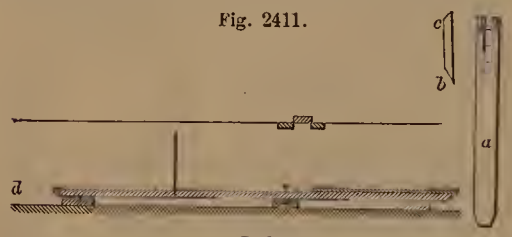
The *clavicytherium* may be considered the original of the whole train of stringed instruments whose strings were mechanically vibrated. See PIANO-FORTE.

The harpsichord introduced two strings to a note, and preceded the piano, from which it differed specially in the mode of vibrating the strings.

It consisted of a harp whose wire strings were touched by quills operated by keys. Each quill was a plectrum, and was a substitute for the human finger, the musical effect being similar to that of the harp, as it was intended to be. The instrument might be called a horizontal harp in a frame, the strings being touched by quills set in motion by the fingers applied to keys on a key-board. We read of it first among the Provençals, the Troubadours who twanged ecstatically.

The *spinet* was so called because its quills or plectra resembled thorns. (*Spina*, Latin, a thorn.) The

Fig. 2411.



Jack.

instrument was invented by the Italians, and was like the harpsichord, but smaller.

The quill was attached to an upright piece called a *jack*, *a*, whose lower end rested on the key which raised it, causing the quill *c* to bend and slip past the string, where it remained so long as the finger was pressed upon the key. In returning, the swiveled piece to which the quill was attached gave way to allow the quill to pass the string, and the swiveled tongue was restored by a bristle *b*, which acted as a delicate spring. A small piece of cloth on top of the jack rested on the wire and acted as a damper.

Whether the modes of *twanging* the strings by a plectrum or quill, in imitation of the action of a harpist, preceded all the devices for *striking* the string, it is not easy now to determine; but the latter mode, which appears to have originated in the *clavichord*, has entirely superseded the quill.

An early and obsolete predecessor of the piano was the *virginal*, which had *keys* and jacks, but only one string to a note. See VIRGINAL.

It is mentioned by Shakespeare, —

"Still virginaling
Upon his palm" *Winter's Tale.*

And also by Gabriel Platte, who, in the succeeding century, describes a dibbling machine as formed of iron pins, —

"Made to play up and down like virginal jacks."

The *clavichord*, *d*, is said to have consisted of a range of brass wires placed above the keys, which latter had wires on the rear ends, acting as hammers upon the strings when the keys were struck. A muffling-piece on the string limited the portion involved in the vibration and acted as a damper.

One mode of striking the wires in this instrument was by a leathern button on the top of a piece of strong wire fixed in the farther end of the finger key. This little device was the simplest possible form of a stringed instrument played by means of keys. The striking part was called a *jack*. It was a favorite instrument more than a century before the invention of the harpsichord, and must be considered the original of the piano-forte.

The pins formed wrest-pins for the strings, which vibrated only while the key was held down, and the place at which the pin struck the string determined the length concerned in the vibration. A damper fixed behind the string acted upon it when the pin quitted the string, the key, in fact, forming one of two bridges, between which the strings vibrated.

The instrument was an important one for several hundred years; the favorite of Bach and of Mozart.

The *hammer-harpsichord* is referred to in the "Giornale d' Italia," 1711, and was the first *piano-forte*, though the name was not given till about fifty years afterwards. It was the invention of Cristofori of Florence; the improvement consisting mainly in pivoted hammers, which were struck by jacks on the keys, and retired immediately from the strings. See PIANO-FORTE.

The pedals were invented by Loeschman.

The *double-harpsichord* had two sets of keys and strings in a set. One key of one set struck two keys in unison; while one key of the other set struck a string tuned an octave higher. A farther change removed one bank of keys, and the three strings were tuned in unison.

Har'row. (*Husbandry.*) The harrow is a large rake, being a frame with teeth drawn over the ground to level it, stir the soil, destroy weeds, or cover seed.

It is a frame, usually of wood, and has downwardly projecting teeth which penetrate the soil. The shapes of the frame are various. The teeth are usually of square bar-iron, sharpened to a point, maintaining the square form. They are set in the harrow-frame so as to move in a direction parallel to their diagonals.

As stated under the appropriate heading, the cultivator is an improved harrow; handles being added to increase its manageability; and colters or shares substituted for straight teeth, thus increasing its efficiency.

Harrows are made with the various modifications mentioned, and others might be cited, but still they are called harrows by their makers, setting classification at defiance. These hybrids are useful and efficient tools, many of them, but it is not easy to give them a "local habitation" or "a name" in a classified digest of machines.

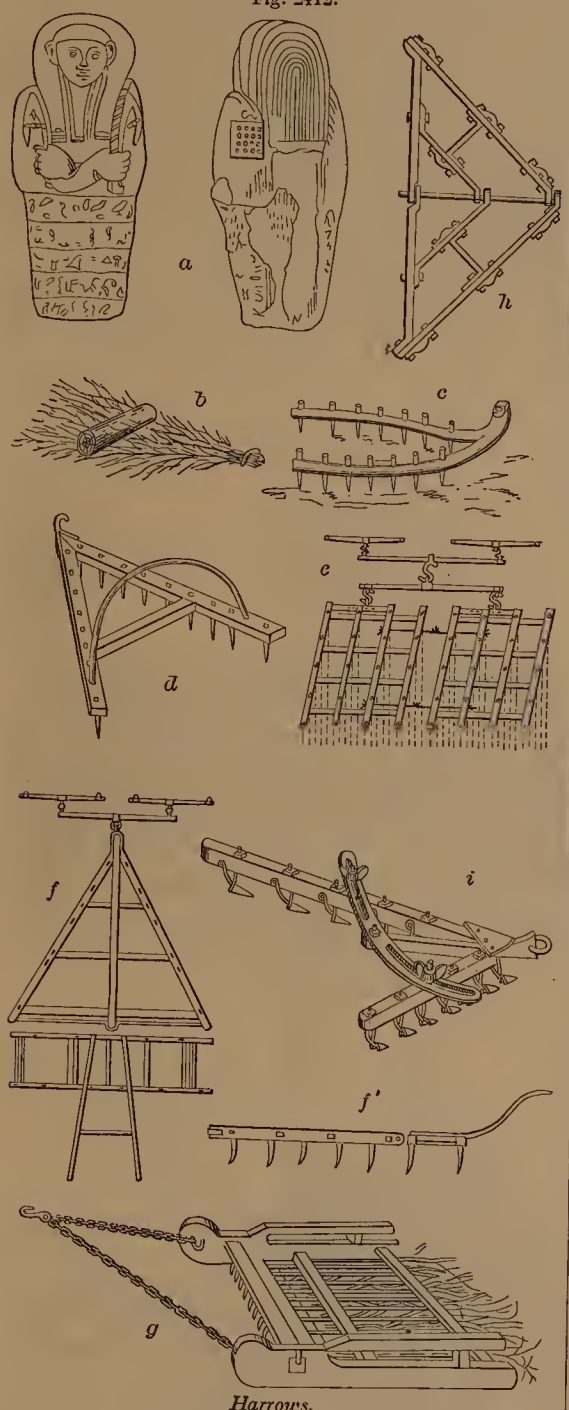
Two notices of the harrow are found in the Bible. In Job is the inquiry, "Will he [the unicorn] harrow the valleys after thee?"

The word is said by some Hebraists to be a mis-

nomer; a seed-covering tool is referred to, drawn by animal power, and may have been a plow. Their thrashing drag would have made a tolerable harrow. It was a frame of boards, studded with spikes. See THRASHING.

The other reference to the harrow occurs in the account of the cruelty practiced by David upon the men of Rabbah, 1033 B. C.: "He cut them with

Fig. 2412.



Harrows.

saws, and with *harrows* of iron, and with *axes*." (1 Chron. xx. 3.) The parallel passage in 2 Samuel xii. 31 states that "he put them under saws and harrows," etc. Adam Clarke disputes the rendering, and declares that the original means he made slaves of them, putting them to work with saws, harrows, and axes. *Quien sabe.*

Although the images of Osiris are represented with a plow in each hand (*a*, Fig. 2412), and something like a harrow hanging by a cord over the left shoulder, still the harrow does not appear to have been in ordinary use in ancient Egypt. In the elaborate sepulchral paintings, the various operations of husbandry are carefully depicted, and these show that the clods were broken by hoes, and the seed was covered by hoes, plows, the tramping of men or animals, and perhaps by dragging bushes over the surface. Being sown on the mud left by the retiring Nile, the seed needed little attention and soon germinated. The amount of mud left by the Nile raises the cultivated land about six inches in a century at Elephanta.

An inscription of the age of the Emperor Antoninus on the pedestal of the vocal Memnon shows that the soil at Thebes has risen seven feet in 1,700 years, say five inches to the century. An excavation at the foot of one of the colossal sphinxes at Karnak shows a deposit of eighteen feet above the layer of spawls and rubbish forming the foundation. Beneath this is an alluvial deposit of unknown depth. The rise of eighteen feet indicates a period of 2,250 years B. C. for the erection of that sphinx. The elevation of the land by the sediment of the inundation decreases southwardly. The periodical rise commences about June 1, it increases for three months, remains stationary about twelve days, and then subsides. The rise is greatest in Upper Egypt, and less towards the mouth. Thirty-six feet rise is a "good rise" at Thebes, twenty-five feet at Cairo. The rise at the Damietta and Rosetta mouths may be about four feet. The land is gradually encroaching on the desert in most places; buildings and monuments originally erected on the barren land outside of cultivation have now a depth of many feet of soil around their bases. Many of the sites of antiquity are now buried. (See Wilkinson.) The amount of land inundated by the Nile is about 5,626 square miles (average). This does not include the river and lakes.

Harrows bore the same part in the operations of husbandry in the time of Pliny (A. D. 79) that they do now. "After the seed is put in the ground, harrows with long teeth are drawn over it."

The common harrow of the Romans was a hurdle, but they also used harrows made of planks studded with iron spikes.

The harrow is represented in the tapestry of Bayeaux, A. D. 1066, and is mentioned by Googe, in his "Heresbachius," A. D. 1578.

An act of the Irish Parliament was passed in 1634, forbidding harnessing horses by the "tayles" to harrows. See notice under HARNESS, p. 1062.

Harrows are made of various forms, and if we reject the harrow, if such it be, on the shoulder of Osiris (*a*), we may suppose it to have been originally a bundle of bushes (*b*) tied together at the butts, and thus dragged over the field. A log on the brush — as we of the West term it — would flatten as well as weight it, and would add to its efficiency. The bush-harrow is very efficient in covering timothy, clover, etc.

Directions for the construction of a harrow are given by an English agricultural writer in 1668, as follows: —

"Get a pretty big white-thorn tree, and make sure that it be wonderful thick, bushy, and rough grown."

In some parts of the north of Europe, the spiky limbs of fir-trees are bound together, and the spurs of the limbs make a reasonably fair substitute for the tines of a harrow.

In another form, the bush-harrow *g* is used under conditions where the teeth of an ordinary harrow

would penetrate too far, as in covering grass-seed. The bushes are cut and so disposed in a frame as to present a moderately level surface of limbs, which, as they pass over the land, reduce inequalities and cover the seed as deep as desirable. The object, of course, in putting land down to grass is to obtain a good level surface over which to mow.

The thrashing-sled of the Egyptians and Syrians, the tribulum of the Romans, may have been used for dragging over the ground to cover seed, but it does not so appear. As stated, the harrow in the time of Pliny had long iron teeth.

A convenient limb of a tree has often furnished a ready frame for a harrow, *c*, which is attached by a clevis to the double tree of the team or the chain of the oxen. In still earlier periods it was hauled by a withe, a grape-vine, or a rawhide rope.

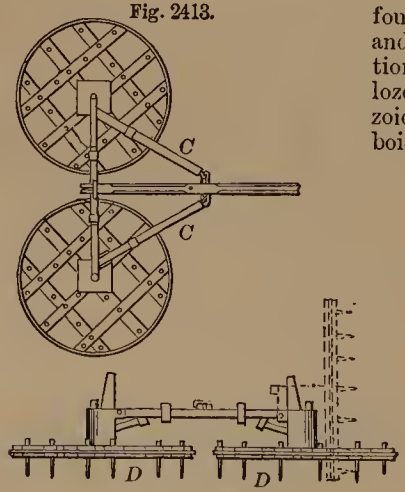
From this the step is easy to the letter "A" harrow *d*, which is a very familiar form in new countries. It is very handy in ground from which stumps have not been eradicated. It is easily lifted by the corner or by the bow.

The usual form of the British harrow is called the Berwickshire pattern, *e*. It consists of two parts joined together by iron rods, having hasps and hooks. Each part consists of four bars of wood connected by cross-bars mortised through them. The former of these are made of 2½ by 3 inch scantling, and the latter of 2 by 1 inch stuff. The bars meet at a certain angle, so that the figure formed is a rhomb, and the teeth are inserted into the bars at equal distances from each other. This obliquity is such that perpendiculars from each of the teeth, falling upon a line drawn at right angles to the line of the harrow's motion, shall divide the space between each bar into equal parts, so that the lines marked by the teeth in the soil shall be parallel and equidistant.

h is a double-harrow with folding sections. *f f'* is another form of double-harrow consisting of a triangular frame to which the team is hitched, and a square frame hinged to the former, so as to be brought into effective position or be laid over the other when not required. The rear portion has handles, and its teeth split the balks between the furrows left by the teeth of the preceding harrow. *f* is a top view, *f'* a side view.

Double-harrows are made in many other forms, two, three, or four leaved, and having sections square, lozenge, trapezoidal, rhomboidal, or triangular. Specimens of each would be given did space permit.

Fig. 2413.



Rotary-Harrow.

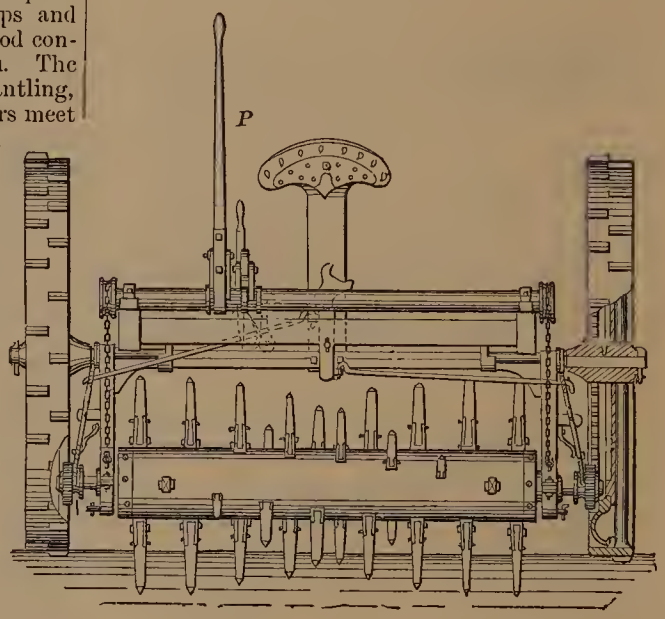
The harrow *i* is for grassy or weedy lands, and has teeth of cultivator form, presenting V-shaped blades which cut at a distance below the surface, say two or three inches. This in many cases is much more effectual than the mere jagged tearing action of simple spikes.

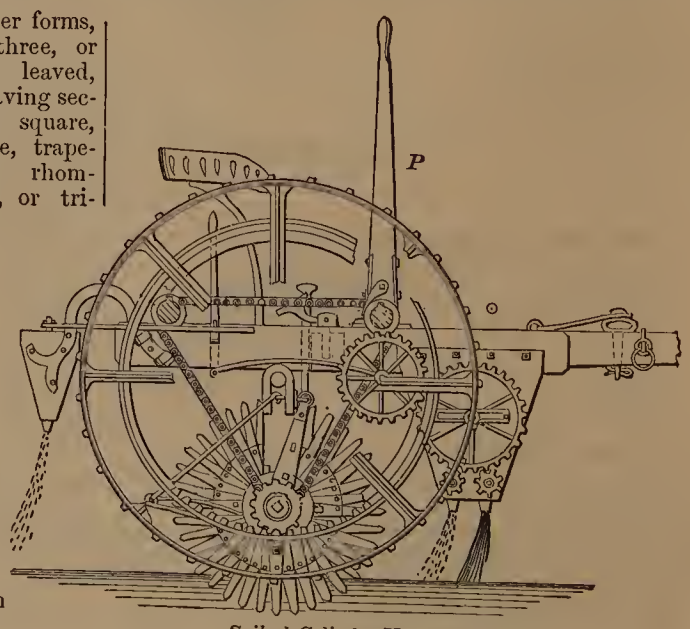
Another kind of harrow is drawn in the rear of and partly suspended from an axle and pair of wheels. This implement has also its proper place in some kinds of soil and modes of tillage.

Rotary harrows are made in many forms, and may have one, two, or more sections which lie flatly upon the ground, as in Fig. 2413. Each section *D* is eccentrically journaled by an upright axis to the frame *C*, and as a consequence of the eccentricity the sections rotate as the harrow advances over the ground. As a greater number of spikes are presented on one side of the axis of rotation than on the other, their hold on the ground is greater, and the lighter side is obliged to rotate forwardly.

The flexible spiked-chain harrow used in England is made of wrought-iron links, so shaped and com-

Fig. 2414.





Spiked-Cylinder Harrow and Seeder.

bined as to keep the harrow stretched, while a certain number of the teeth, at regular intervals, have dependent spikes.

The spiked-cylinder harrow, known in England as the Norwegian harrow, has three sets of rowels placed in gangs upon an iron axle. It is used for reducing the land to a fine tilth for the reception of seed, which it does to a depth of three or four inches in soil which is in suitable preliminary order. No amount of drawing spiked tools over a wet clay bed will make friable soil, and the use of this tool, as well as of crushing-rollers, is a thing to be done in the right time and place. Fig. 2414 shows an American form of this tool, which is intended for sowing fertilizers, grain, and grass-seed, and harrowing in the same. A portion of one driving-wheel is broken away in the upper view, in order to expose the internal cog-gear by which the spiked cylinder is rotated, as it does not depend upon its contact with the ground for its rotation. The feeding devices for seed and fertilizer are driven by chain-band connection with a wheel on the spiked drum. The spiked cylinder may be raised from the ground by the lever *P*, or adjusted as to depth of penetration.

Har'vest-er. (*Agriculture.*) A machine for cutting grain or grass. See MOWER; REAPER.

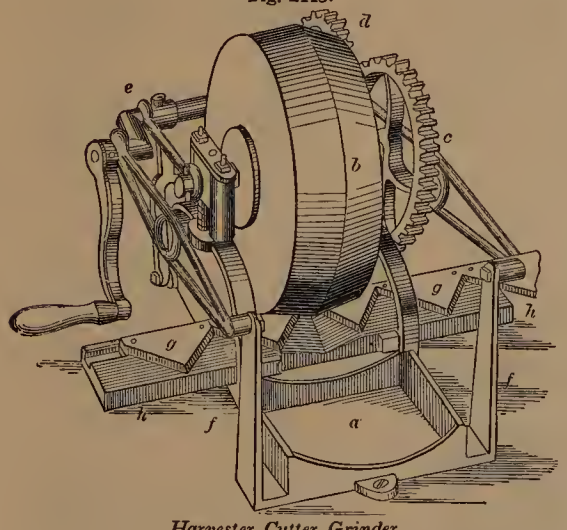
See also under the following heads: —

Bean-harvester.	Guard-finger.
Binder.	Heading-machine.
Cane-harvester.	Hemp-harvester.
Clover-seed harvester.	Lawn-mower.
Corn-harvester.	Rake.
Dropper.	Reel.
Finger.	Sward-cutter.
Flax-puller.	

Har'vest-er-cut'ter Grind-er. A machine adapted to the grinding of the section knives of harvesters, which are riveted to the knife-bar.

In Fig. 2415 a bed *a* supports a sliding carriage on which is the doubly beveled grindstone *b*, having a gear-wheel *c*, which engages with a wheel *d* on the shaft *c*. From the uprights *f* pivoted connections run to a crank at each end of the driving-shaft,

Fig. 2415.



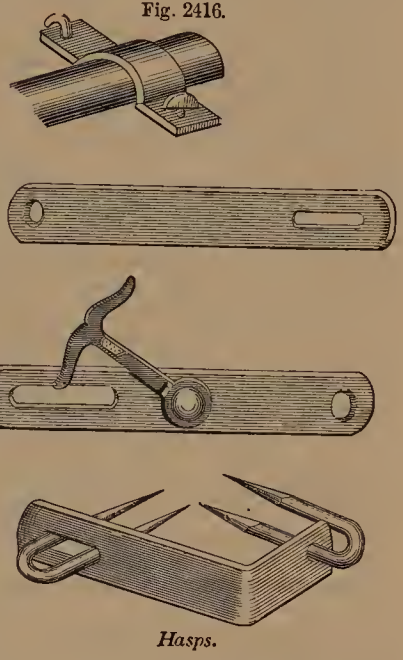
Harvester-Cutter Grinder.

and from each end of this shaft similar connections are made with the axis of the grindstone. The knives *g* are secured to the guide *h* fixed to the frame at a suitable angle. On turning the crank the stone is caused to rotate as usual, and is reciprocated back and forth, insuring the even grinding of the teeth, from root to point, and preserving the shape of the stone.

Har'vest-ing-ma-chine'. See MOWER; REAPER. See HARVESTER for list.

Hasp. 1. A fastening. A clamp or bar fast at one end to an eye-bolt or staple, the other end passing over a staple, where it is secured by a *pin*, *key*, *button*, *fore-lock*, or *padlock*.

Fig. 2416.



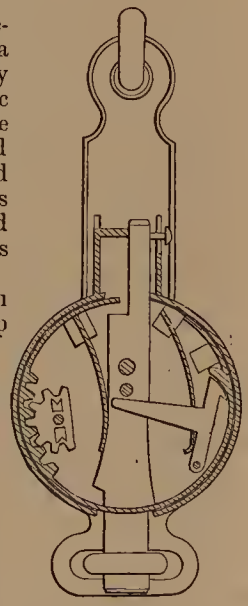
Hasps.

2. A scarifier for grass lands.

3. A spindle for thread or silk.

Hasp-lock. One in which the hasp, which is attached to the trunk-lid, itself carries the locking-device. In the example, the bolt is shot longitudinally so as to protrude from the hasp and enter the staple. The locking-circle has an internal cog-gear *V* operated by a cog-segment *C*, and has a locking-tooth *W* and a pivoted engaging-lever *L*.

Fig. 2417

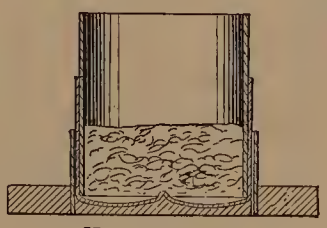


Hasp-Lock.

Has'sock-fil'ler. A device consisting of a curb and a charging cylinder, whereby the stuffing is packed into the cover. A tube is slipped inside the ottoman or hassock, and both are placed in the ring and upon the bottom piece. As the filling is introduced and pressed down, the tube is gradually withdrawn.

Has'ten-er. A kitchen stand before the fire to keep the radiated heat around the joint which is being roasted.

Fig. 2418.



Hassock-Filler.

Hat. 1. A head-covering with a crown, sides, and continuous brim. Made of cloth, felt, straw, silk, splints, grass, etc.

Felt hats are as old as Homer. The Greeks made them in various forms; skull-caps, conical, truncated, narrow or broad brimmed (*petasus*). The Phrygian bonnet was an elevated cap without a brim, the apex turned over in front. This form is

very old, and indicates an inhabitant of Asia Minor. It is known now as the *cap* of liberty. In Rome, the ceremony of manumission of a slave, the head was shaved and a *cap* presented as an emblem of freedom. An ancient figure of Liberty, of the time of Antoninus Pius, A. D. 145, holds the cap in the right hand.

We even find them with brim and no crown. Tied before or behind, — we thought this was quite modern. A broad-brimmed hat is shown in the sculptures of Karnak.

Herodotus refers to the soft hats of the Persians. They wore round-top caps without peaks, somewhat resembling the modern *fez*. Hats encircled with plumes were the head-dress of the Lycian contingent in the army of Xerxes.

Herodotus said that the skulls of the bareheaded Egyptians were so baked that they would hardly decay, and were, in this respect, very different from the Persians, who protected their heads and kept them so soft that they soon rotted. He observed it, he says, on an old field of battle in Egypt; the former were as hard as a brick, and the latter decayed.

The broad-brim hat (*causia*) was worn by the Macedonian kings. It is said by Smith (Dictionary of Greek and Roman Antiquities) to have been made of felt. It is shown on a medal of Alexander I. of Macedon. It was adopted by the Romans, especially Caracalla.

In the accompanying cut are shown some of the forms which the ancient felt hat assumed. The *pilcus* (Latin) was the common felt *cap*, the *fess* of the modern Greeks, the *fez* of the Turks. The *petasus* (Greek) was a *hat;* it had a brim; its name, in fact, comes from a word whose root meaning is extension, dilation.

a is from a sepulchral bas-relief in Bœotia.

b is a fisherman's cap, from a statue in the Townley collection, British Museum.

c is a coin of Bruttium, South Italy; the figures are Castor and Pollux. With us, *castor* means a *hat*, from the beaver (castor, from a Sanscrit word meaning *musk*), which supplies the best material.

d is a head of Dædalus, from a bas-relief in the Villa Borghese collection. This form is still worn by the shepherd boys in Asia Minor.

e is a head of Ulysses, from an ancient lamp. It represents him as tied to the mast while he listens to the songs of the sirens.

f is the modern Greek peasant's cap, introduced for comparison.

g is from a parian marble bust of Paris, wearing the Phrygian cap, and now in the Glyptothek, Munich.

h is from a coin of the Emperor Verus, now in the British Museum, and representing *Armenia capta*. The captive wears a *plug* hat.

i represents Dacia in mourning, with a pudding-crown hat on. It is the obverse of one of Trajan's coins.

j is from a coin of Antoninus Pius, and represents the goddess of liberty.

k is from a statue of the sleeping Endymion in the Townley collection of the British Museum.

l is from a bas-relief in the Vatican, and exhibits the head of a shepherd.

m shows the shepherd Zethus with his hat slung behind his back. Borghese collection.

n, horseman with a petasus. Parthenon.

o p, silver coins of Ætolia in the British Museum.

q, from a vase of Sir W. Hamilton's.

r is from an ancient marble bust.

s t are from coins of ancient Italy, and representing heads of Mercury.

In the thirteenth century, Pope Innocent IV. allowed the cardinals the use of scarlet cloth hats.

Fig 2419.

Ancient Hats.

The introduction of felt hats is credited to a Swiss, in Paris, in 1410, and in 1440 it is said to have become a common article of wear for travelers.

In 1449, Charles VII. made his triumphal entry into Rouen, wearing a felt hat lined with red velvet and surmounted with a fine plume of feathers. This set the fashion, and hats soon superseded the old chaperons and hoods.

Chaucer, who wrote during the latter part of the fourteenth century, represents the merchant as wearing a Flanders beaver hat. This may antedate our Swiss friend mentioned above.

The hats referred to in the reign of Richard II. (1385) were probably of cloth.

Felt hats are stated by one authority to have been first made in England in 1470; and by another authority (Stow) to have been first made there, by Spaniards, in 1510. Before this time the people, both men and women, wore close woolen caps; originally of cloth and afterwards knit. Knitting is quite a modern art.

Two centuries since, hats were customarily worn indoors.

"Home to bed; having got a strange cold in my head, by flinging off my hat at a dinner, and sitting with the wind in my neck."—PEPYS'S *Diary*, September 22, 1664.

"Home to supper, having a great cold, got on Sunday last, by sitting too long with my head bare, for Mercer [his wife's maid] to comb [his hair?] and wash my ears."—*Ibid.*, January 25, 1664.

"This day Mr. Holden sent me a bever, which cost me £4 5*s.*"—*Ibid.*, 1641.

In Lord Clarendon's essay on the decay of respect paid to age, he says that in his younger days he never kept on his hat before those older than himself, *except at dinner*.

Hats, besides those of straw and similar material, are made of fur, principally that of the Russian hare or coney, mixed with a small proportion of wool or cotton.

There is a legend that the process of felting was accidentally discovered by St. Clement, who, having put some rabbits' fur in his shoes to protect his feet during a long journey, found at its conclusion that the fur had become compacted into a homogeneous mass.

The use of the fur of the beaver, which certainly dates back prior to 1585, threatens now to become obsolete, it being superseded to so great an extent by the imitation made by covering a body with silk plush.

In any process of making felt or fur body hats, the first operation is weighing out a sufficient quantity of the material to make a single hat-body.

In the hand process, the fur is bowed by being placed in a heap over a table above which is suspended the *bow*, much resembling a fiddle-bow, though having but one string which is vibrated by the workman striking it with his thumb until the hairs are brought into a light even layer. The wool is then treated in a similar way with a larger bow, and the two layers of fur and wool are, by means of a light wicker frame adapted to receive the material, placed one over the other and again bowed, when the mass is compressed by the wicker frame, and afterward by an oil-cloth pressed upon it by the hands until the fibers have become sufficiently united to bear handling.

A triangular piece of brown paper is then placed above it, over which its edges are folded, and the whole is wrapped up in a damp cloth and manipulated until the fibers have become thoroughly intertwined and the body is brought into a triangular form. This is called *basoning*.

In the next process, called *planking*, the body is alternately immersed in a kettle of very dilute sulphuric acid, to which beer-grounds or wine-lees are added, and then worked upon an inclined plane at the side of the kettle until it is shrunk to half its former size and much increased in thickness, the operation being completed by the aid of a rolling-pin which smooths and compacts the felt. The body is then dried in a stove, and sized with a brush dipped in shellac dissolved in alcohol, and again dried; any superfluous sizing is removed by dipping in an alkaline solution and scraping. Beaver fur is applied to the exterior by being mixed with fine cotton, and the two are felted, in manner similar to that described, into a thin sheet, which is affixed to the exterior of the body by manipulating it in the boiler and on the plank; in this process the cotton separates. The body is yet of a conical shape, and is partially brought into proper form by hand, and then stretched upon a cylindrical block, after which it is dyed by boiling in a solution of copperas, verdigris, gall-nuts, and logwood in water. It is now drained, dried, and removed from the block, and *finished* by placing over a jet of steam which softens it, when the brim is turned up, the stiffening of the crown inserted, placed upon a block, the nap smoothed, and a glossy surface imparted by means of warm and damp hair-brushes and a plush-brush called a *velours* (sometimes *lewer* or *lure*), finishing with a hot iron. The trimmings and lining are next sewed in, and the hat is finally warmed and such slight variation of shape imparted as the style requires.

In the present mode of making felt hats, after being *carroted* by treatment with a solution of mercury and nitric acid, in order to render the felting easier, the fur, when dry, is removed from the skin and assorted, according to quality, into back, belly, and side, the latter being the finest. These are mixed as may be required, according to the quality of the hat, and farther mixed in the proportion of 4 to 5 ounces, that being the quantity required for a hat body, with from ¼ to ½ ounce of fine carded cotton. This mixture is placed in a box above a toothed picker, revolving with great velocity, which seizes the material and conveys it on an endless belt to another picker. The agitation caused by the current of air from these assists in intermingling the ingredients.

The *stock*, as it is now termed, is next passed through a series of toothed rollers, where coarse materials and dirt fall into trays beneath, while the finer portions are forced out at the farther extremity of the machine. The stock, which is now said to be *blown*, is next placed on the feeding-apron of the *forming-machine*, in quantities just sufficient for one hat-body. Here it is drawn in between two horizontal, felt-covered feed-rollers, and seized by a cylinder provided with several longitudinal rows of stiff brushes, and making about 3,000 revolutions per minute. By this a current of air is generated, which scatters the stock and blows it out through a vertical slot at the top of the machine against a revolving copper *cone* having a great number of perforations, and partially exhausted of air by a rapidly revolving fan. When the stock from the first machine is thus all withdrawn and compressed against the side of the *cone*, a wet cloth is placed over it; a metallic cover is slipped on over this, and the whole transferred to a tank of hot water. The *mat* is next removed from the cone, small portions of stock added to strengthen any thin spots which may be detected, and it is rolled and worked in a piece of blanket. After a little manipulation, it is ready for the process of felting, which is done by experienced workmen, by constant rolling and dipping in hot

water for several hours, for the purpose of farther thickening and fulling it; or, in other words, felting the fur and reducing the large cone to the proper dimensions for making a hat. After being properly sized or felted, it is passed to the shaving-room, where the outer surface is shaved with a sharp knife by a skilled workman, to remove whatever hair may yet remain in the fur. It is then returned to the kettle for a second sizing, to farther close up and strengthen the felt. After the farther operations of being stiffened, cleaned, blocked, colored, shaped, and pounced, the body is ready for the finishing process.

The great improvement of the perforated exhausted cone, with its attendant slotted blowing cylinder, is due to H. A. Wells, by whom it was patented April 25, 1846. Williams, in England, had previously employed a partially exhausted cone in connection with a carding-machine for making hat-bodies from tow or waste silk. See BLOWING-MACHINE, p. 307.

In this country, fur, mixed with a little Sea-Island cotton, is generally employed. The forming and sizing of the body are done in a way precisely similar to that of felt hats, but a much less quantity of stock, from 1 to 1¼ ounces, is used.

After sizing, it is dipped into a solution of shellac and alcohol, drawn over a block and the brim flattened. A thick stiffening is placed in the crown and on the brim, and the body again blocked, slightly moistened, and ironed into shape. The brim is ironed on the brim-board, sand-papered smooth, again ironed and coated with a sizing of fine glue.

After this two coats of shellac varnish are applied and the body is ready to receive its silk plush covering. The plush for this purpose is imported from France and Germany, the former of superior quality.

The material is cut into two pieces which form the upper and under surfaces of the brim, and other two which constitute the body and crown. The under brim in one circular piece is first put on, and afterwards the upper brim, sewed to the crown and side piece; the whole forming a sort of bag, which is drawn over the body. The operation of sewing requires great neatness, to conceal the seam, and neatness is also required to conceal the joint where the two ends of the piece forming the side unite. This is effected by cutting off the overlapping part very exactly at the joint and brushing the nap over it; the application of a hot iron unites the plush to the body. The hat-band conceals the junction of body and upper brim, and the binding that of the upper and lower brim pieces.

The hat is finished by rubbing with small wire hand-cards and stiff brushes, after damping with a sponge, and afterwards ironing it. This straightens and lays the nap, a mixture of camphor and alcohol is applied to soften any adhering dirt, and the hat is then placed in the *luring*-machine, — an apparatus similar to a lathe, — in which the hat on its block is caused to revolve against pads of stiff woolen plush; this removes all dirt and water stains. The final gloss is imparted with the hot iron, after which it is trimmed. From the hands of the finisher the hat passes to the trimmers and curler, where the finishing touch is given and the brims molded into the shape, as the style and fashion may dictate, bringing out the Hogarth lines of beauty in their curves and curls, and adapting them to the taste of the correctly dressed gentleman of the day.

Two kinds of bodies are employed for silk hats. One consists of stiffened muslin, and the other of felt or fur.

The muslin, or, as it is termed, the gossamer body, is said to be the lightest and most durable of the two kinds used, and is rapidly superseding the fur or felt body for general wear.

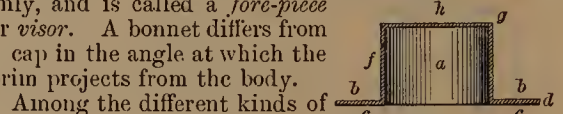
Silk-hat making is known to those connected with the trade as an art, and was styled by them in olden times, "the art and mystery of hat-making."

The parts of a hat are as follows: —

a, body or crown.
b c, brim.
b, upper brim.
c, under brim.
d, rim.
The banding-point, or break of the band, is at the junction of the brim and crown.
f, side crown.
g, square. *h*, tip.

A cap differs from a hat in the shape of its brim, which projects from one side only, and is called a *fore-piece* or *visor*. A bonnet differs from a cap in the angle at which the brim projects from the body.

Fig. 2420.



Hat.

Among the different kinds of hats may be cited, the

Cloth-hat.
Cork-hat.
Embossed-hat.
Felt-hat.
Fur-hat.
Leather-hat.
Paper-hat.
Silk-hat.
Spring-brim hat.
Straw-hat.

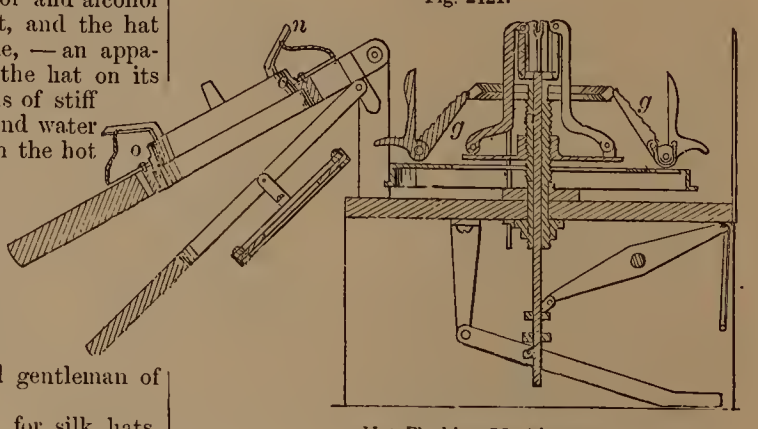
Collapsible hats, for opera or traveling, are made with springs or of springy material. See OPERA-HAT.

Panama hats are made of the leaves of the pandamus or seren pine (*Carludovica palmata*). These are gathered before they unfold, the ribs and coarser veins are removed, and the rest, without being separated from the base of the leaf, is reduced to shreds. After having been put in the sun for a day, and tied into a knot, the straw is immersed in boiling water until it becomes white. It is then hung up in a shady place, and subsequently bleached for two or three days, after which the straw is ready for use. The plaiting of the straw commences at the crown and finishes at the brim, and is a very troublesome operation. The hats are made on a block placed on the knees, and require to be constantly pressed with the breast. The coarser hat is usually finished in two or three days, but the finest often requires as many months.

2. (*Tanning.*) The stratum of bark on the top of a pile of hides and interposed bark, filling a tan-pit.

3. (*Metallurgy.*) A depression in the tunnel-head of a smelting-furnace to detain the gases.

Fig. 2421.



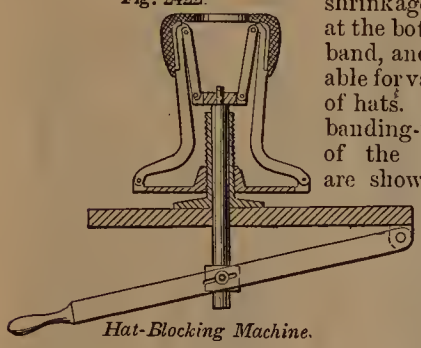
Hat Blocking Machine.

Hat-block. A form upon which the hat is finished. It is usually made of five pieces, four outside segments and a square central or key-block.

In finishing the exterior, a *spinner* is used as a stand, being simply a flat oval table, the face of which corresponds to the curve of the brim. It is removed when the under brim is to be worked.

Hat-block'ing Ma-chine'. A machine for blocking hats, stretching out the crown by means of expansible framework, and stretching out the brim by clamps, which take hold of the brim, and are then raised from an inclined to a horizontal position. The expansible framework is raised and lowered by a screw stem, so as to adjust it to varying depths of hats. The ring serves several purposes, giving pressure to the clamps by means of springs, and forming a point of attachment for the inclined projections for giving the edge of the brim an extra stretch to overcome the shrinkage. The rim *o* at the bottom *breaks* the band, and is changeable for varying sizes of hats. Fig. 2421, the banding-ring and a part of the stretching-arm are shown as laid over away from the cone; it is brought into operation upon the hat-body by swinging over, bringing the stretchers *n n* between the part *g g* and the banding-ring *o*, upon the band of the hat.

Fig. 2422.

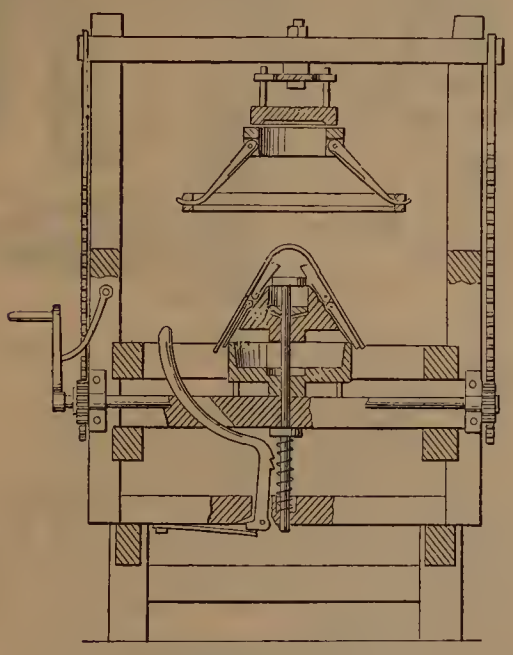


Hat-Blocking Machine.

Fig. 2422 shows the rubber over the crown stretchers to prevent undue corrugating of the body.

In Fig. 2423 the *cone* to form the body is placed upon the block *E*, which has two circumferential series of slanting ribs above it. When the carriage

Fig 2423.



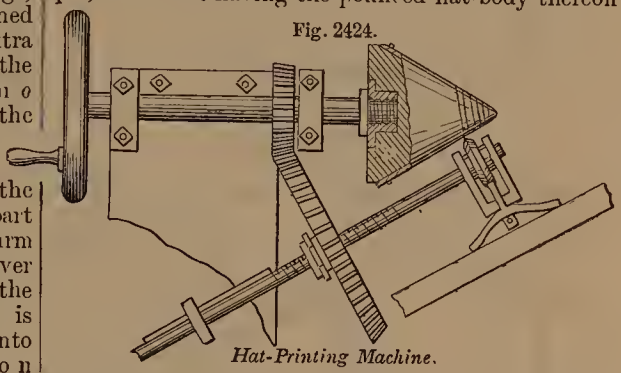
Boyden's Hat-Blocking Machine.

is raised so as to bring the cone within the hollow former above, the piston *D* expands the upper series of radial arms, distending the crown, which is thereby pressed against the sides of the block *T T*, and flattened against the crown-piece *H*; the crown and sides are then blocked. The brim is distended by the rising of the ring *L* against the inside edges of the lower and outer series of hinged arms, which are thus pressed against the under side of the brim and press the latter against and between the arms *V* of the former above.

Hat-bod'y. The entire body in an unfinished state, as the *cone* from a forming-machine, or the *shell* or *carcass* upon which plush is attached to make a silk hat; or the beaver hat before napping; or a cloth hat before stiffening.

Hat-bod'y Print'er. A machine for printing a pattern on the exterior of a hat-body, to produce an ornamental effect or imitate a fabric. In the example, the block having the pounced hat-body thereon

Fig. 2424.



Hat-Printing Machine.

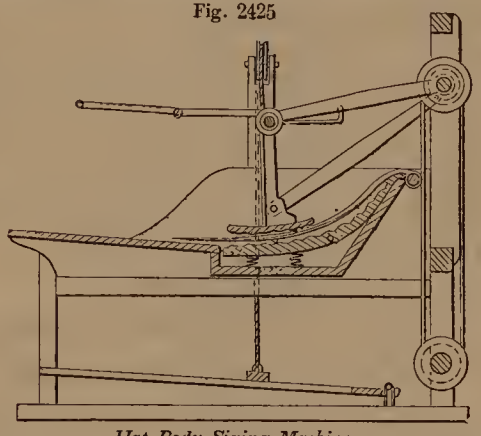
is screwed upon the end of a shaft, which is rotated in conjunction with a printing-roller, which may have more or less rapid feed given to it.

Hat-bod'y Siz'ing-ma-chine'. Sizing is a term synonymous with *hat-shrinking* and *hat-planking*. For hand process see HATTER'S BATTERY.

An operation for shrinking or reducing the hat-body to the proper size and form for making the finished hat. The apparatus consists of an elastic bed in a trough containing hot water, and a semicircular rocker, by which a kneading operation is performed on the body.

The elastic support of the corrugated bed sustains the lower end of the latter above the surface of the

Fig. 2425

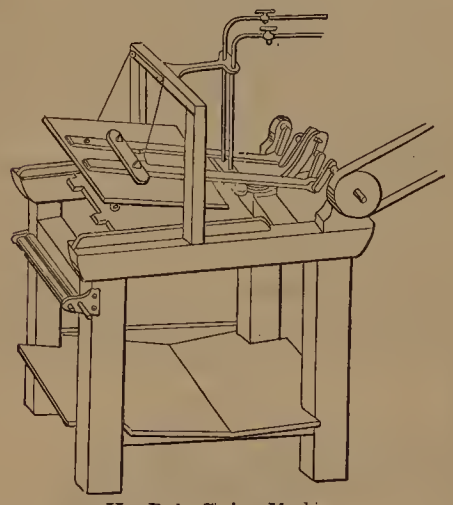


Hat-Body Sizing-Machine.

liquid, so that the roll of hats may be adjusted upon the bed without exposing the hands to the hot water. The handle, pivotal shaft, and impelling springs enable the machine to be operated by hand.

In Fig. 2426, the table has a simple horizontal reciprocation, and the platen an oscillating as well as a reciprocating motion, being rigidly attached to the pitmans. Jets of hot water or steam may be applied to the *bat* from pipes which end in a finely perforated box.

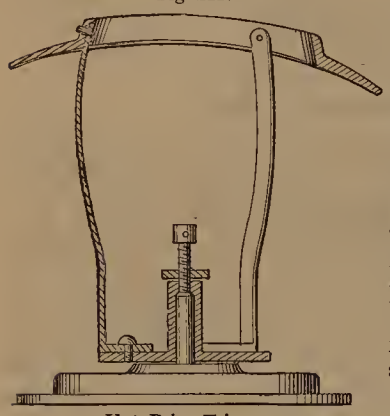
Fig. 2426.



Hat-Body Sizing-Machine.

Hat-brim Trim'mer. A pattern which determines the point at which the brim is to be trimmed. The operation is commonly performed by a *rounding-jack*, which is a curved knife carrying a gage which bears against the band point while the hat is upon the block, and, being moved around the body, cuts the brim of an equal width all round.

Fig. 2427.



Hat-Brim Trimmer.

Hat-brush. A soft, drawn brush, of horse or goat's hair.

Hat-brush'ing Ma-chine'. A machine in which brushes are used to equalize and polish the nap, pile, or exterior fibrous matter forming the surfaces of hats. They sometimes rotate in contact with the body, or it is rotated while they are held in contact with it. After the forming operation, the brushing-machine removes the dust or liberated fiber.

Hatch. 1. A stop-plank falling in vertical grooves in a frame, and supporting a head of water in a weir. A *sluice*-gate. A *flood*-gate.

2. A grated weir for a fish-trap.

3. A breast-high or half door.

4. A shutter to cover a hatchway, or scuttle, in a ship's deck or warehouse floor.

5. A hatchway or opening in a deck or floor.

6. An opening into a mine.

Hatch-bar. (*Nautical.*) The bars by which the hatches are fastened down.

Hatch'el. (*Fiber.*) An instrument for cleansing flax or hemp from the *hards*. It consists of a number of teeth set in a board, upon which the hank of fiber is thrown and dragged through, so as to comb it straight and remove the coarser portions. A *hackle*.

Hatch'et. (*Carpentry.*) A one-handed chopping-tool.

Hatchets of the stone age have been found with eyes for the reception of the helve. No such perforation is found in any bronze axe or hatchet of the immense period during which the cutting tools were formed of this metal. Bronze was always cast, and it seems wonderful that no one thought of casting it with an eye. Natural holes in stones were utilized for eyes; two flint hatchets in the museum of Copenhagen are examples.

The early history of our race is written in the tools of stone, bone, and bronze. A few leaves from the chapters to be found in all our museums are transferred to these pages.

a is a copper celt from Waterford, Ireland, resembling in shape the earlier stone tools, such as axes, adzes, chisels, hoes, for the chase, war, carpentry, and agriculture.

b is a winged celt from Ireland, *c* a socketed celt from the same country.

d c f show the modes in which the celts *a b c* were stocked.

Fig. 2428.

Celts and Hatchets.

These celts vary in size from an inch to a foot in length. *g* is a stone celt.

h is a celt-mold from Ireland.

i is a decorated bronze celt from Ireland.

k l m are Danish celts of bronze.

n is a stone axe from Ireland.

o, a stone hatchet found in county Monaghan, Ireland, yet mounted in a pine handle 13½ inches long. Almost none of these weapons are found with holes for the handles. See AXE.

p is an ancient stone hatchet found at the streamtin works, Morbihan.

q is a bronze hatchet from Morbihan.

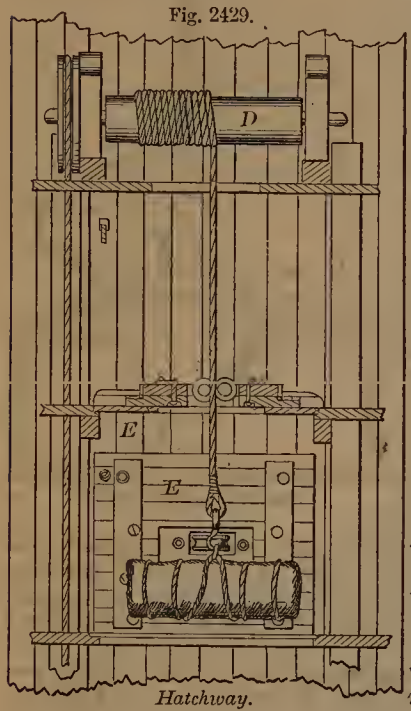
r is the Roman *securis*. It had a single edge, or a blade and poll, as represented in the figure. When it had a blade on each side of the haft it was known as *bi-pennis*. See DOUBLE-BITTED AXE.

s is a shingling hatchet.

Hatch'ing. (*Engraving.*) A style of drawing or engraving in which the shading is performed by lines crossing at angles less than 90°.

Hatch'way. 1. (*Shipbuilding.*) One of the large square openings in the deck of a ship whereby freight is hoisted in or out, and access is had to the hold. The coverings are *hatches*. These are fastened down by *battens*.

Fig. 2429.



Hatchway.

There are four pieces in the frame of a hatchway. The fore-and-aft pieces are called *coamings*, and those athwart ship are *head-ledges*. The *head-ledges* rest on the beams, and the *coamings* or *carlings* extending between the beams.

The hatchways are *fore*, *main*, *after*, as the case may be, according to the size and character of the vessel.

2. An opening in the floor of a warehouse for the passage of goods. The illustration shows a part of three floors, the windlass *D* above, the hatch of the next floor closed, a floor yet lower has the hinged hatch *E* lifted and laid back against the wall.

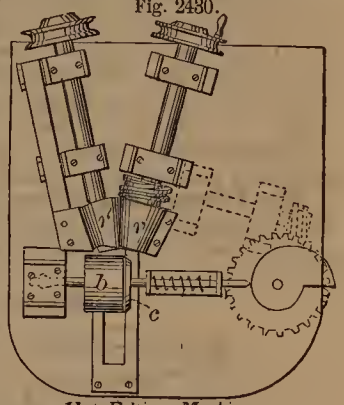
Hat-con-form'a-tor. A machine of French origin, by which the oval shape of the head is ascertained. It consists of a series of sliding arms, radially arranged in a frame, and carrying at their upper ends sharp points. When applied to the head as is a hat, the arms are thrust outward by contact with the head, and assume a position corresponding to the exact conformation thereof. While thus held an impression is taken upon a slip of paper pressed upon the points. This paper is trimmed to the form delineated by the points, and becomes a pattern by which an adjustable block is set for use in reshaping the form of a finished hat.

Hat-die. A block for holding a hat while pressing. Synonymous with HAT-MOLD (which see).

Hat-em-boss'ing. A means for beautifying the appearance of a hat, by producing a pattern upon its exterior by raising and depressing different parts of its surface. Generally done on a pattern-block upon which it is pressed. Dies are sometimes employed. A pressing tool, running in a lathe, is also used to impress a pattern.

Hat-felt'ing. A mode of forming hats by placing a disk of felting material between surfaces which by a rubbing and drawing action felt the fibers and cause the hat to gradually assume the required shape. In the example, the circular piece of felting material is placed between the disk *e* and *block b*, its outer portion being embraced between the conical rollers *r r'*. The parts being set in motion, the block is gradually slipped along its axis, causing the felt to assume the shape of the sides of the block. When the latter has been moved a distance equal to its length, the hat is formed, the remainder of it that is between the manipulators *r r'* constituting the brim.

Fig. 2430.

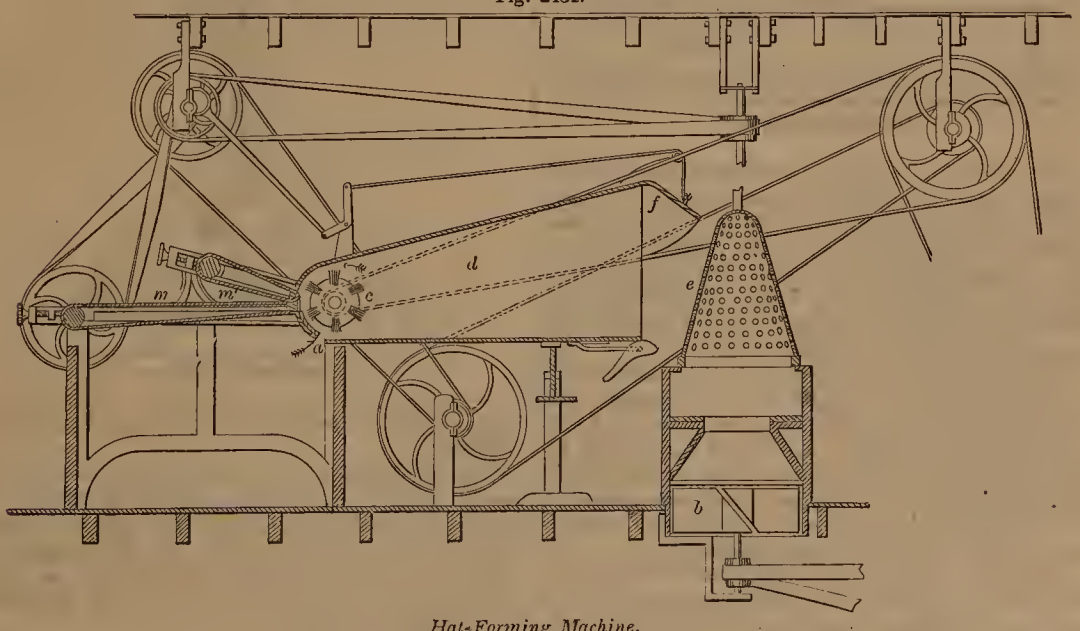


Hat-Felting Machine.

Hat-fin'ish-ing. The operations which complete a hat for market, — such as brushing to lay the nap, and ironing to smooth and impart a gloss to it; or pouncing to even the surface; or brushing to remove the dust; or dyeing and trimming.

Hat-form'ing Ma-chine'. Slivers of wool are taken from the doffer of a carding-engine and wound

Fig. 2431.



Hat-Forming Machine.

in different directions upon a cone, which revolves and traverses or vibrates to and fro, by which motions the filaments of wool are crossed at different angles, and perfect felting is accomplished.

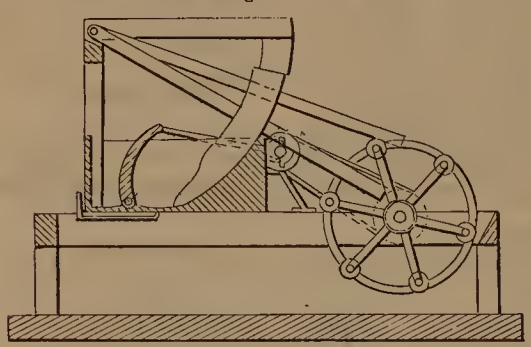
This class of machines is now superseded by that shown in Fig. 2431, which is a machine for loosening-up fiber and depositing it on a former, so as to form the hat-body. Various machines of this kind have been invented, embracing the same general principles, but differing in detail. That illustrated was patented by H. A. Wells, April 25, 1846. In this the fur, in regulated quantity, is supplied to the machine between a pair of feeding-belts *m m'*, and caught from the lips of the belts by a rotating brush or picker *c*, which separates the fibers and delivers them into the tunnel *d*, air being drawn through the aperture *a* by means of the draft caused by a fan-blower *b*, rotating with great velocity. The cloud of fur is drawn through the tunnel *d*, and deposited upon the revolving perforated cone *e*, from which the air is exhausted by the fan *b*. A vibratable deflector *f* hinged to the tunnel *d* governs the discharge of fur from the tunnel, so that an increased thickness may be given to the lower part of the hat-body.

When the charge or given quantity of fur to form a body has been deposited on the former, it is covered with a conical cloth or felt cap over which a metallic covering is placed and the whole removed from the machine, and immersed for a short time in a hot-water bath, to contract and compact the material. See also BLOWING-MACHINE, page 307.

The succeeding processes are those ordinarily employed in hat-making. See HAT; FELTING.

Hat-full'ing Ma-chine'. The function of a fulling-mill in hat-making is to thicken or consolidate the body. It commonly consists of two or more

Fig. 2432.

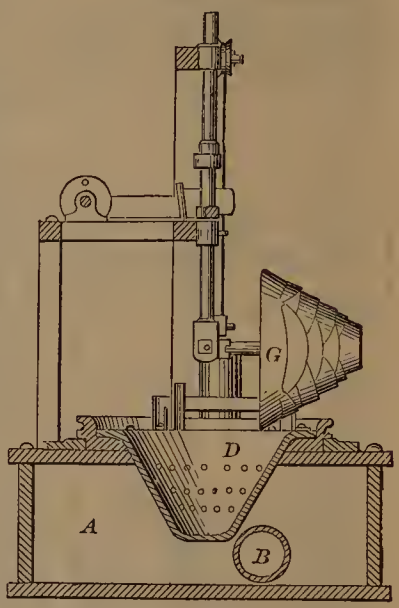


Hat-Fulling Machine.

sets of beaters or hammers, successively raised and dropped upon the mass of hats contained in the trough, where they are agitated or turned by mechanical means so as to constantly present new surfaces to the fulling-stocks. In the example the movement of the swinging side of the fulling-box causes the mass of hats to pass around regularly to insure equal action on all their parts.

In Fig. 2433 the *bat* is laid over the basin *D* and the forming-block *G* brought over it. Steam is admitted through perforations in the mold, and also in the *former*, if desired. The mold and its rim rotate continuously. The *former* has an adjustable reciprocating rotary motion, and also an up-and-down vertical one; the shingles or curved lapping surfaces serve to crowd down and aid in fulling the bat. By an automatic motion of a weight outward upon the beam-lever, a blow of gradually increasing force is given to the falling cone *G* as the work proceeds. *A* is the steam-chamber, *B* the steam-pipe.

Fig. 2433.

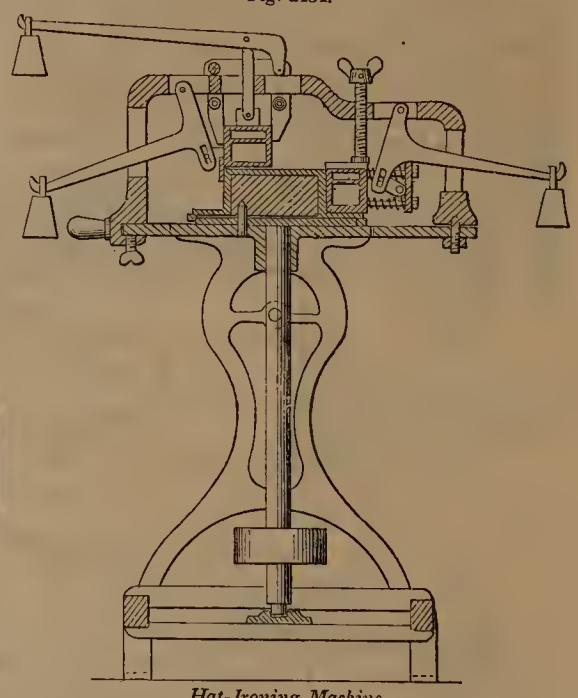


Hat-Fulling Machine.

Hat-hard'-en-ing Ma-chine'. *Hardening* or *basoning*; a preliminary felting operation which converts the fibers into a fabric dense and tenacious enough to enable it to be handled and put through the felting process. In cones from the forming-machine, it is usually done by an auxiliary cone moved over that on which the body was formed. Other bodies are steamed and rolled up in cloths (basoning-cloths). Flat bats are hardened between a table and a flat platen having short, quick reciprocating motion. See Emmon's patent, April 19, 1853.

Hat-i'ron-ing Ma-chine'. A machine for performing the ironing formerly done by hand, by

Fig. 2434.



Hat-Ironing Machine.

which the final operation of finishing a hat is accomplished.

The block supporting the body rotates at a high speed, while hollow irons, heated by interior gas-jets, steam, or hot air flowing through, or by heated slugs introduced within them, are held against the whole surface by pressure of a weight or spring. The tip-iron usually has a lip on one side, which bears over the square.

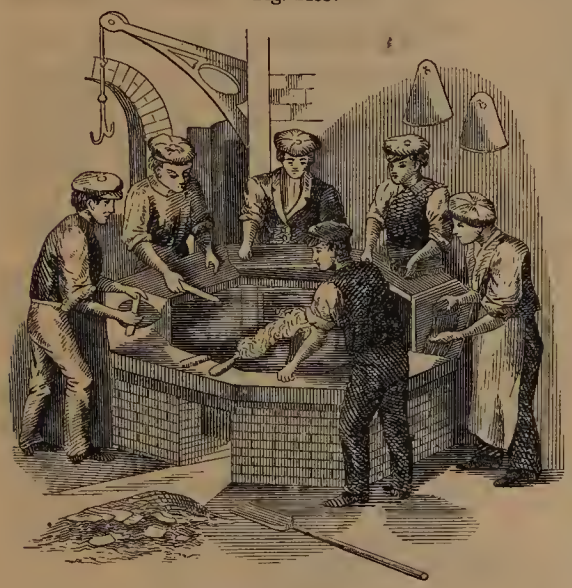
The under brim is either finished by hand or by inverting the block on the machine, so that an iron may bear upon it. In some instances the block is so supported on its spindle as to allow an iron to bear on the under brim at the same time that the crown is being treated.

In the example, the blocked hat revolves on a turn-table; the irons are pendent from an upper bridge-frame, and their pressure is regulated by levers and counterweights; the irons are heated by gas-burners.

Hat-mak'ers' Bat'ter-y. (*Hat-making.*) A large boiler with a surrounding set of benches for a number of workmen. The water has a small quantity of sulphuric acid to enable the fur to felt more readily.

At the battery the conical hat-body and the sheet of fur *napping*, each previously prepared, are united, so that the latter forms a fur covering to the former. The junction is accomplished by laying the napping

Fig. 2435.



Hat-Makers' Battery.

on the body, pressing, rubbing, and rolling with a pin. Boiling-hot water is sprinkled over them from time to time, by means of a *stopping* brush, and when a certain degree of cohesion is obtained the conical hat is ready for *shaping*.

The effect of the manipulations is to drive the butt-ends of the filaments into the interstices between the fibers of the body (see FELT), and it is persevered in no longer than is sufficient to give the nap a good hold on the body.

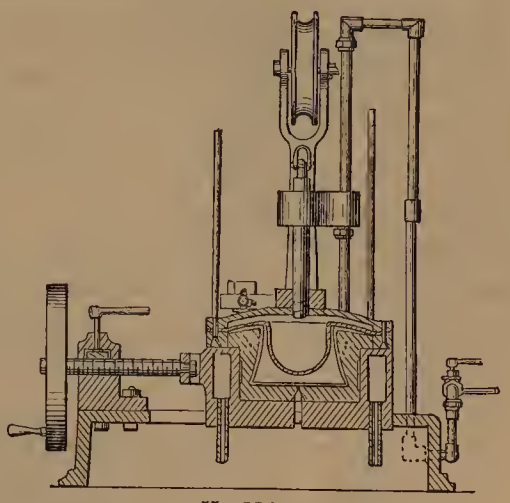
A wooden tool held in the palm of the workman's hand is the means of rubbing, and is held on by a string. It is called a *glove*.

Hat-meas'ure. A device by which the size of the oval head opening is ascertained. Usually a circular graduated ribbon, the ends of which slide in each other. See also HAT-CONFORMATOR.

Hat-mold. The die in which a hat or bonnet is formed or shaped by pressing. In the example, the *bat* to form the hat is shown as being driven into the heated mold by means of the pressure of a liquid introduced above an elastic diaphragm above the bat. See HAT-PRESSING MACHINE.

Hat-nap'ping Ma-chine'. A felted body is dipped into boiling water and its nap drawn out or carded up by a small hand-card. The process of

Fig. 2436.



Hat-Mold.

scalding in napping is described in English patent 7397 for 1837. Known also as *ruffing*.

Hat-per'fo-rat'ing Ma-chine'. A machine for cutting a multiplicity of fine holes in the hat-body to provide for ventilation.

Hat-plank'ing. A finishing felting operation. See FELTING.

The hat-body being *basoned* or *hardened* is passed through a cistern containing a heated acidulated water with dregs of beer, or other planking liquor, and between two series of pressing rollers, by which the fibers are knitted together or consolidated into felt, when they are ready for the blocking.

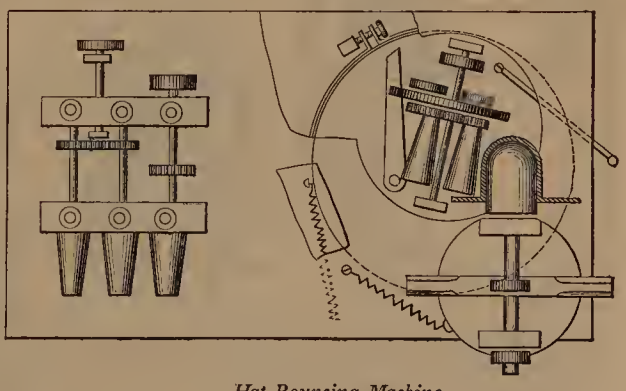
In hat-planking machines the bodies are repeatedly passed through a boiling acidulated bath and under pressure, being frequently *crozed*. See also HAT-BODY SIZING-MACHINE.

Crozing or *crosing* is refolding a hat-body so that in passing many times through a felting-machine it may present new surfaces to be acted upon.

Hat-poun'cing Ma-chine'. A machine for evening or equalizing the surface of a felted hat. It consists of a roller covered with sand or emery paper, and rapidly revolved in contact with the surface, by which the projecting fibers are ground off until the surface fibers are of equal length.

In the example, the cones are covered with sandpaper, and are mounted on shafts which have their bearings in a revolving disk in connection with a swivel plate and an adjustable revolving block on

Fig. 2437.



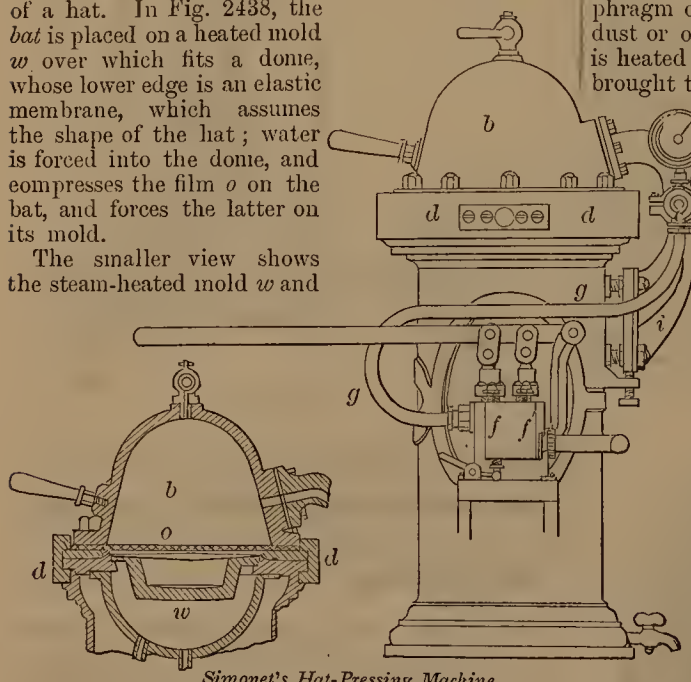
Hat-Pouncing Machine.

which the hats are presented to the pouncers. By the combined action of the feed and pouncing rollers

the brim is subsequently revolved automatically and operated upon by the pouncing cones.

Hat-press'ing Ma-chine'. A machine for bringing a *bat* or *cone* of hat-making material to the form of a hat. In Fig. 2438, the *bat* is placed on a heated mold *w* over which fits a dome, whose lower edge is an elastic membrane, which assumes the shape of the hat; water is forced into the dome, and compresses the film *o* on the bat, and forces the latter on its mold.

Fig 2438.

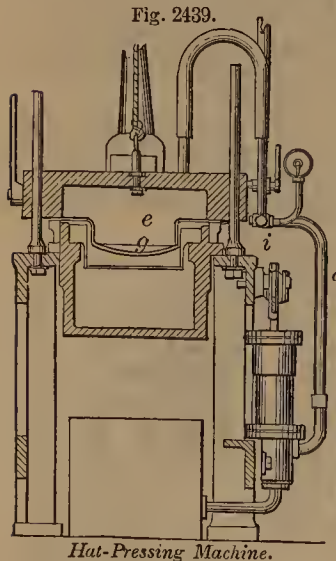


Simonet's Hat-Pressing Machine.

The smaller view shows the steam-heated mold *w* and dome *b* in section, while the larger view is a side elevation. *f f'* are the force-pumps by which water is forced into the dome *b* through the bent pipe *g* and trunnion-tube *c*, which is on an adjustable bracket *i*; the mode of connection allowing a vertical motion to the dome in closing and opening, and a horizontal motion when securing the foot of the dome in the ring *d* by means of a bayonet-joint attachment.

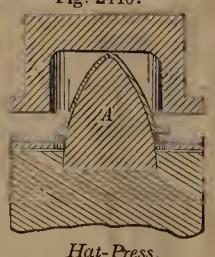
In Fig. 2439, the hat *g* is shown in process of extension downward to fill the hat-shaped mold. The pressure of water is at the first derived from a head, but as greater force is required, the cistern tap is closed and the force-pump is

Fig. 2439.



Hat-Pressing Machine.

Fig. 2440.



Hat-Press.

brought into action, injecting water through pipe *d* into the dome *c*; at *i* is a connection with a manometer which indicates the pressure.

In Fig. 2440, *A* is a compressible block of rubber, which, under pressure, expands to fill the whole interior of the hollow die and press the hat-cone against the surface, while the brim is held between yielding surfaces which preserve its shape.

Fig. 2441 is a machine in which a paper, straw, or cloth hat is brought into the desired form in a hollow die, by means of a plunger formed of a diaphragm of rubber distended by packing with sawdust or otherwise. The chamber *C* behind the die is heated by steam or hot water, and the parts when brought together are secured by a bayonet-joint.

Hat-pro-tect'or. A cover approximating the shape of the hat, and applied to it to protect it in inclement weather.

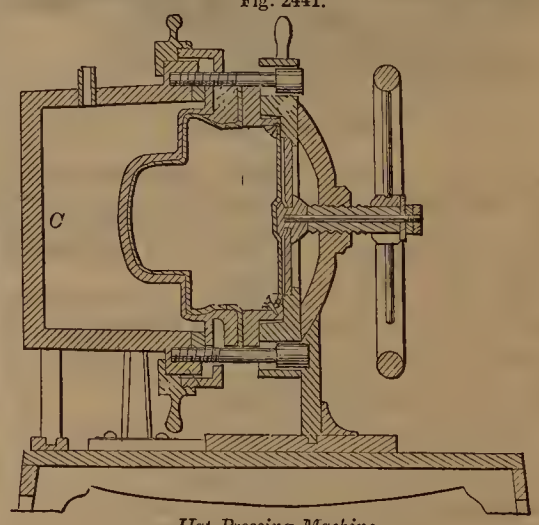
Hat-rack. A piece of hall furniture having pegs for holding hats.

Hat-shap'ing Ma-chine'. A machine for bringing the hat-body from the form of a cone to the hat shape desired. The same as HAT-PRESSING MACHINE (which see).

Hat-stiff'en-ing Ma-chine'. A machine with two compartments, one containing thin and the other thick size. Above its partition a pair of squeezing-rolls are arranged. The hats are dipped in the thin size, passed through the rolls, and then the brims (which require to be the stiffest) are dipped in the thick size, and again pressed.

Hat-stretch'ing Ma-chine'. A machine having a series of radially arranged arms, hinged to a head-block *b*, so as to be expanded. They stretch out the hat-cone, which is placed over them, and prepare it for blocking. In the example, Fig. 2442, the block is raised into contact with the stretched top of the hat, and then

Fig. 2441.

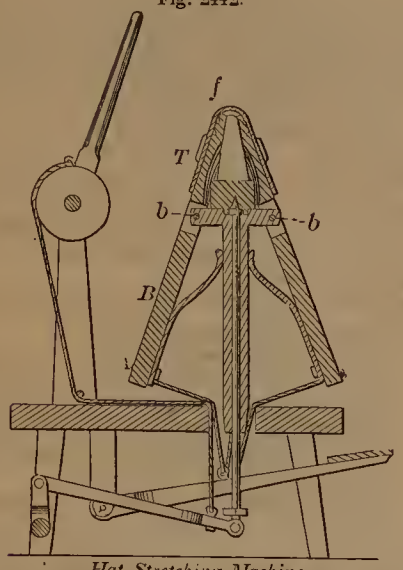


Hat-Pressing Machine.

pushed up by means of a lever, so as to draw it up. The rubber bands fit on the body, and holds it when the stretcher-levers *B* are separated at their upper ends. The hat-cone *f* is shown as clamped to the conical system of levers by the band *T*.

In Fig. 2443, the pieces *b d' d'* are adapted to receive a cone supporting both the crown and brim portions; rising with the cone, they carry it against two other sets of ribs or rollers m^3 m^3 radially arranged, by which contact the body is crimped or stretched so as to have the requisite fullness to be

Fig. 2442.



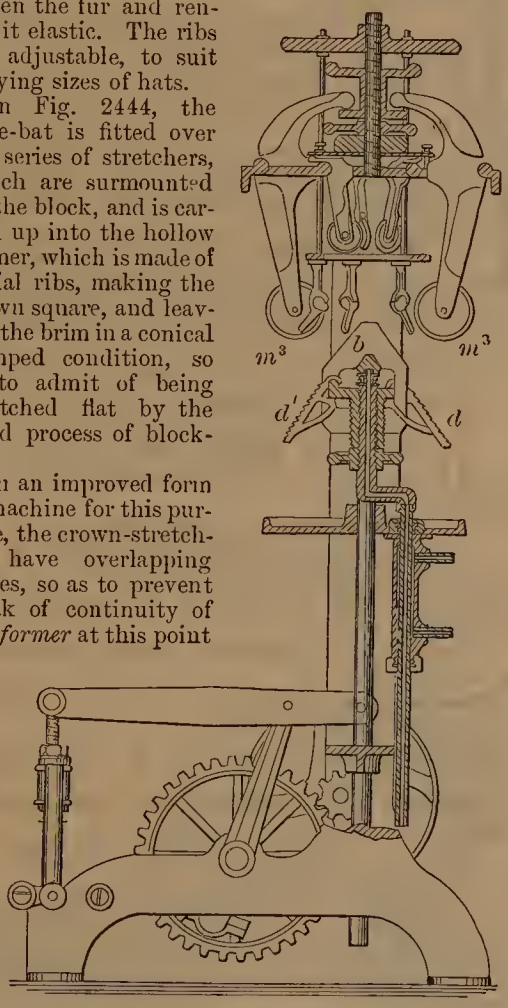
Hat-Stretching Machine.

brought into the hat form over a block. Jets of steam are introduced through the spindle to soften the fur and render it elastic. The ribs are adjustable, to suit varying sizes of hats.

In Fig. 2444, the cone-bat is fitted over the series of stretchers, which are surmounted by the block, and is carried up into the hollow former, which is made of radial ribs, making the crown square, and leaving the brim in a conical crimped condition, so as to admit of being stretched flat by the hand process of blocking.

In an improved form of machine for this purpose, the crown-stretchers have overlapping plates, so as to prevent break of continuity of the *former* at this point

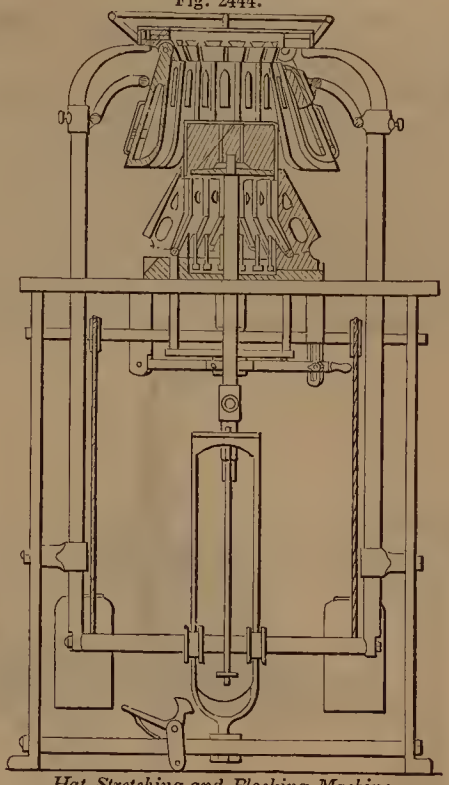
Fig. 2443.



Hat-Stretching Machine.

when the parts are distended. This is also accomplished by an india-rubber cap. When the brim-stretchers clamp the brim on arriving at a horizontal plane, they expand radially, drawing the body against the banding-ring, stretching the brim circumferentially, pulling material out of the side-crown, which is thereby stretched.

Fig. 2444.

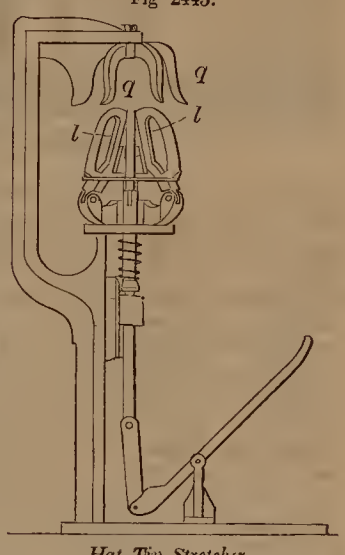


Hat Stretching and Blocking Machine.

Hat-tip Press. One in which gold printing is performed on fabric for hat-tips. The type are of brass, and kept hot. The gold-leaf is laid on the type. The leather or fabric has an adhesive material applied to it, so that the gold will remain on the impressed part and the remainder may be brushed off.

Hat-tip Stretch'er. A machine adapted for stretching the tip of the cone, so that it may be blocked flat. The top is held by the clamp, so that when the treadle is depressed and the stretchers *l* rise, they reach the hat and then expand, passing between the pendent arms *q* and crimping the tips.

Fig 2445.



Hat-Tip Stretcher.

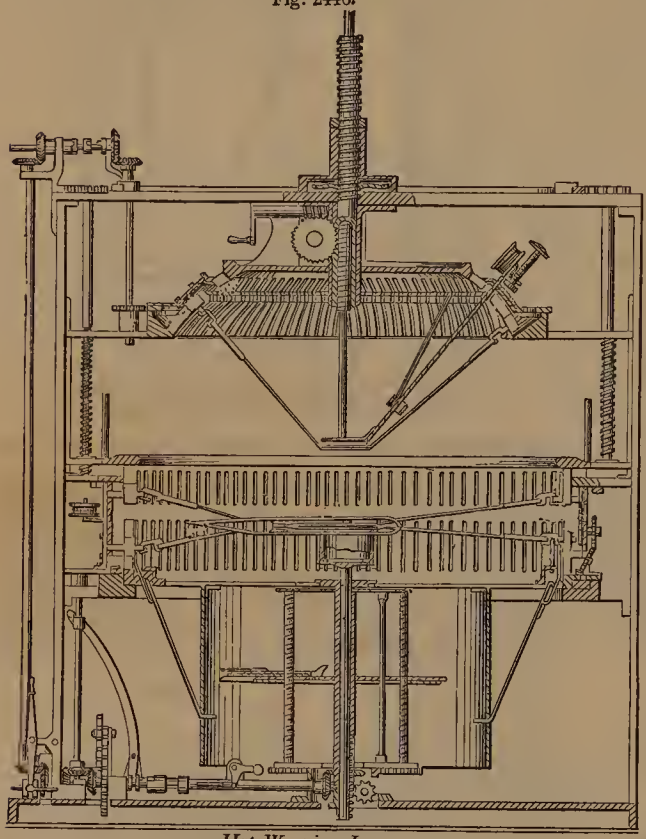
Hat-ven'tila'tor. A means for promoting a circulation of air through a hat while in wear.

The simpler form is an aperture at the top of the crown, frequently provided with a means for closing it up. An orifice extending wholly or partially around the head opening, and formed by a perforated block interposed between the *sweat* and the *body*, acts in conjunction with the *tip* opening. The simplest and most common form is a covered crimped wire sewed between the *sweat* and *body*. The side crown is frequently filled with fine perforations, and in one

instance a stiff body pierced with large holes is covered with an open woven fabric, the pattern of which conceals the perforations.

Hat-weav'ing Loom. The warp strands for the hat are attached to carriers placed opposite each other in a circular series of partitions. The top of the crown is first woven, the warps being horizontal and moved to cross the path of the moving filling. When the top is completed the warp-carriers are removed to the upper series of partitions, and a circular or oval plate at the bottom of a follower gages the size of the crown; then, to weave the brim, the warp-carriers are removed to the lower series of

Fig. 2446.



Hat-Weaving Loom.

partitions, the crown being fitted to a hat-shaped block. During the weaving, additional warps and warp-carriers are thrown into action automatically. The edge of the brim is finished by hand, after the hat is removed from the machine.

Haul. (*Rope-making.*) A bundle of three or four hundred parallel yarns ready for tarring. Being dipped in a tar-kettle, the haul is dragged through a *grip*, *gape*, or sliding nipper which expresses superfluous tar.

Haul-up Gear. (*Saw-mill.*) A machine for dragging up logs from a fore-bay, pond, or log-yard, to be placed upon the log-carriage.

Haunch. (*Architecture.*) The shoulder of an arch between the *crown* and the *springings*. The *flank*, *haund*, or *hance*.

Haut'boy. (*Music.*) A wooden musical instrument played with a reed, and resembling a clarinet. Called also *oboe*.

Haute-pace. (Or *half-pace.*) A raised floor in a bay-window.

Hav'er-sack. 1. A strong linen bag for containing the rations of a soldier on the march or detached duty.

The haversack of the Roman soldier was an osier basket with a long neck. Sometimes, as on the Column of Trajan, a wallet carried on the spear. Its contents were salt meat, cheese, onions, and olives, and it held sufficient for three days.

2. A gunner's case for carrying a charge from the chest to the gun. See GUNNER'S HAVERSACK.

Hawk. (*Plastering.*) A piece of board ten inches square, and held by a handle at the bottom; it is used to hold a small quantity of plaster, and is grasped by the plasterer's left hand, while his right wields the trowel.

Hawk-bill. A pliers with curved nose, to hold pieces in blow-pipe soldering.

Hawk-bill-tooth Saw. A saw having a curving, hooked saw-tooth, somewhat resembling the upper mandible of the hawk.

Hawk'er. (*Nautical.*) A vessel built like a *pink*, but rigged like a *hoy;* that is, having a narrow stern and *sloop-rigged*.

Hawks-bill. (*Horology.*) A catch-piece attached to a vibrating arm, which acts as a detent in the rack of the striking part of a clock, and assists in effecting the proper number of strokes.

Hawse. (*Nautical.*) *a.* That part of a ship's bow in which are the *hawse-holes* for the cable.

b. The situation of a ship moored with anchors from each of the bows.

Hawse-bag. (*Nautical.*) A canvas bag stuffed with oakum, to stop a hawse-hole in heavy seas.

Hawse-block. (*Nautical.*) A block for stopping the *hawse-hole* when the cable is unbent and the ship at sea. Also called *hawse-plug*, *buckler*, etc.

Hawse-hole. (*Shipbuilding.*) A hole in the bow through which a cable or hawser passes. In iron ships it is a cast-iron tube having rounded projecting lips, inside and outside.

When the cable is unbent, the hole is stopped by a *hawse-block*, or *hawse-plug*.

The *hawse-holes* in large ships are four in number, the foremost pair being for the *bower-cables*, and the aftermost pair for the *sheet-cables*.

Hawse-piece. (*Shipbuilding.*) *a.* One of the cant-frames standing next to the knight-heads, and fitting close together, so as to form a solid mass of timber for the passage of the hawse-holes.

b. A wale on a ship's bow, which is pierced by the hawse-hole.

Hawse-pipe. (*Nautical.*) The tube lining a hawse-hole in a ship's bow.

Hawse-plug. (*Nautical.*) A HAWSE-BLOCK (which see).

Haw'ser. (*Nautical.*) A small cable, used in warping and mooring.

A *clear* hawse is when two cables are down and diverge from each other.

A *foul* hawse is when they are twisted by the swinging of the ship at her moorings.

When simply crossed, it is called *cross*-hawse; another cross makes an *elbow;* another makes a *round-turn*.

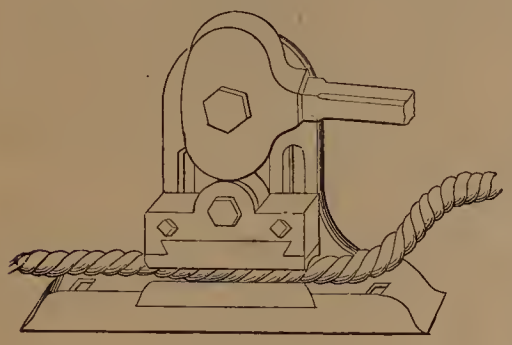
Disengaging it is called *clearing hawse*. Slackening it is called *freshening hawse*.

Speaking generally, a hawser is not over ten inches in circumference. Above this it is a cable. The *laying*, however, is not to be disregarded.

Haw'ser-clamp. (*Nautical.*) A gripper for a

hawser, to keep it from veering out. In the example, the lever is recessed so as to form a flange which acts as a cam upon a pin for the purpose of raising the guide with the movable jaw. The guide has a

Fig. 2447.



Hawser-Clamp.

rib running in a slot in the upright bracket to which it is bolted. See CABLE-STOPPER.

Haw'ser-laid. (*Rope.*) Rope made of three strands, of three yarns each, *laid up* into a rope. The twist of the strands is the reverse of the individual yarns.

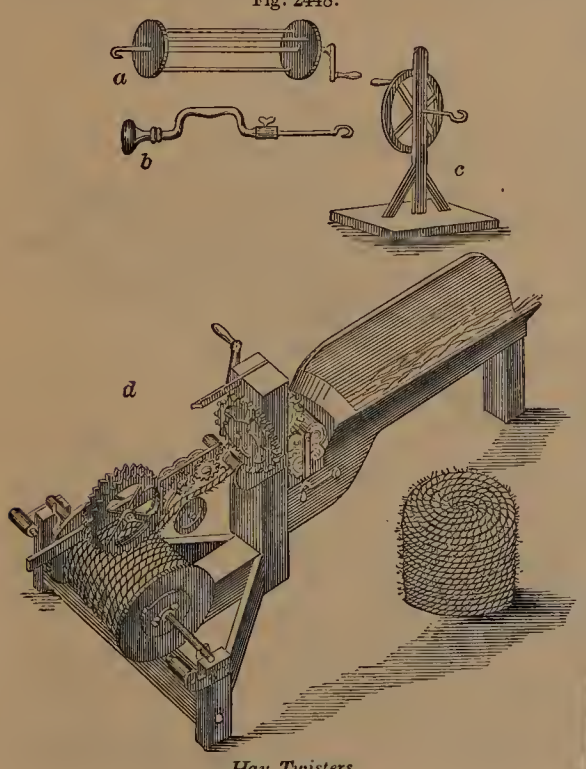
Shroud hawser-laid has four strands.

Three *hawser-laid* ropes are laid up into a *cable*, the twist being again reversed.

Hay-band Ma-chine'. (*Husbandry.*) Hay or straw bands are useful in binding an occasional bunch or sheaf of straw or hay, or for throwing over a new stack to hold the cap on until it has time to settle. They are made by drawing and twisting, as in the more elegant and precise operations of spinning cotton and wool.

A common device for this purpose is a reel or lantern cylinder *a* held under the left arm, while the right hand turns the crank and the axis, on whose end is a hook to which a wisp of hay is attached.

Fig. 2448.



Hay-Twisters.

The operator walks away from the bunch of hay, or an assistant pays out the hay in the quantity required.

A brace and hook *b* answer the same purpose.

Instead of the brace and hook, another device *c* may be used, in which the axis of the twister is mounted in a stand. One person turns the wheel and another catches a wisp into the hook and then backs out, like a rope-maker.

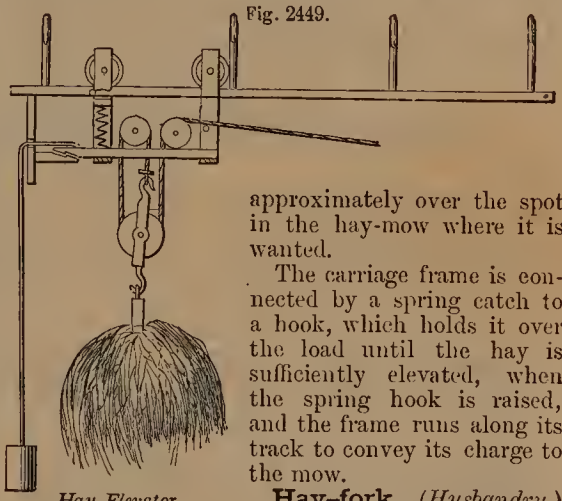
d is a machine which makes hay rope and winds it up into a coil for transportation. Rollers draw the hay from the trough, and the twisting is effected by a planetary action of the rollers longitudinally. It is then coiled on the reel.

Hay-cap. (*Husbandry.*) A piece of canvas to lay on the top of a haycock to shed rain.

Hay-cut'ter. (*Husbandry.*) A box in which hay is cut into chaff. There are many forms: wheels with radial knives, which cut into each other's intervals, or against a cylinder of rawhide; guillotine knives with a shear cut; rotary shearing knives, which glance athwart the throat at which the compacted mass of hay emerges, and so on. See STRAW-CUTTER.

Hay-el'e-va'tor. (*Husbandry.*) A means for lifting a forkful of hay, and conveying it to a place

Fig. 2449.



Hay-Elevator.

approximately over the spot in the hay-mow where it is wanted.

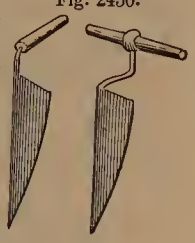
The carriage frame is connected by a spring catch to a hook, which holds it over the load until the hay is sufficiently elevated, when the spring hook is raised, and the frame runs along its track to convey its charge to the mow.

Hay-fork. (*Husbandry.*) 1. A hand fork, with two or three tines, for stirring or pitching hay.

2. A fork elevated by a rope and horse, in unloading hay from a wagon to a mow, or *vice versa.* See FORK.

Hay-hook. (*Husbandry.*) An implement for pulling hay out of a mow or stack, instead of throwing it off the top, or cutting it off with a hay-knife. Such hooks are common in the Eastern States, but not in the West. Such a hook is described and pictured, page 893, Tome 5, "Encyclopédie de l'Agriculteur," Paris, 1861.

Fig. 2450.



Hay-knife. (*Husbandry.*) The *hay-knife* has a straight blade, one edge, and a bent shank, so that the hand does not come in contact with the upright face of the stack. The same effect is obtained by placing the handle at right angles to the plane of the blade.

The hay-spade has a sharp blade, a handle, and a tread. One form has a re-entering angle with sharpened edges. It is said to be peculiarly efficient.

Hay Knives.

Hay-load'er. (*Husbandry.*) A device attached to a wagon to collect or raise the hay from the swath, windrow, or cock, and deposit it on the wagon.

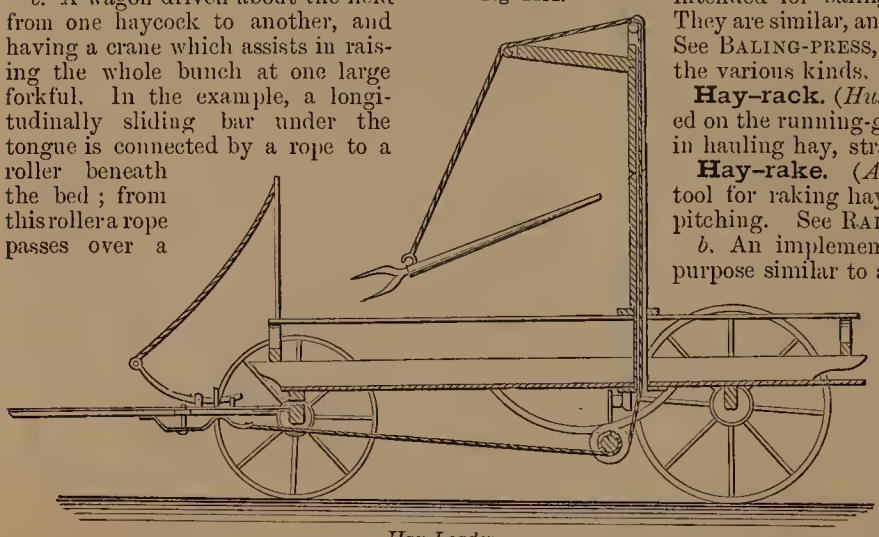
There are several forms : —

a. A rake trailing behind the wagon or alongside of it, and a traveling band with teeth carrying up the hay and dropping it into the wagon rack or bed. (See Fig. 2458.)

b. A drag-rake gathering the hay, and a crane on the wagon lifting it therefrom.

c. A wagon driven about the field from one haycock to another, and having a crane which assists in raising the whole bunch at one large forkful. In the example, a longitudinally sliding bar under the tongue is connected by a rope to a roller beneath the bed ; from this roller a rope passes over a crane to the loading-fork. The draft on the rope applies the rubbers to the wheels.

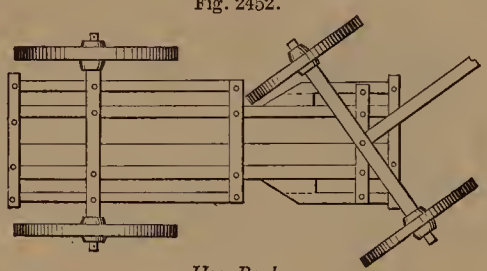
Fig. 2451.



Hay-Loader.

d. A crane on wheels or a sled. A mast or tripod on a sled.

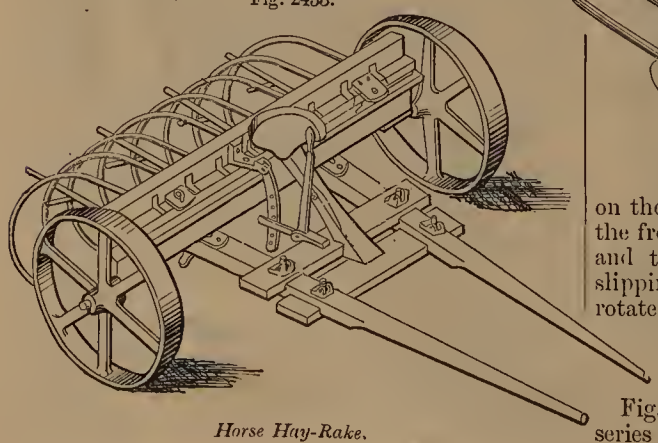
Fig. 2452.



Hay-Rack.

Hay-mak'ing Fur'nace. Mr. Mechi writes to the "London Times" that he shall hereafter arrange to make his hay by furnace-heat. The apparatus consists of a coke-furnace, and a fan by which the heat is driven through a small chamber filled with grass. In fifteen minutes the grass is converted into hay, sweeter and greener than can be made by sun-drying. The apparatus works in all weathers, and dries grain, corn, and roots as well.

Fig. 2453.



Horse Hay-Rake.

Hay-press. (*Husbandry.*) A press for baling loose hay for greater compactness in storage and transportation. The old form is the lever or screw ; latterly much ingenuity has been exercised in this direction, some machines being especially intended for baling hay, others for cotton. They are similar, and are considered together. See BALING-PRESS, in which place are cited the various kinds.

Hay-rack. (*Husbandry.*) A frame mounted on the running-gears of a wagon, and used in hauling hay, straw, sheaves, etc.

Hay-rake. (*Agriculture.*) *a.* A hand-tool for raking hay into windrow ready for pitching. See RAKE.

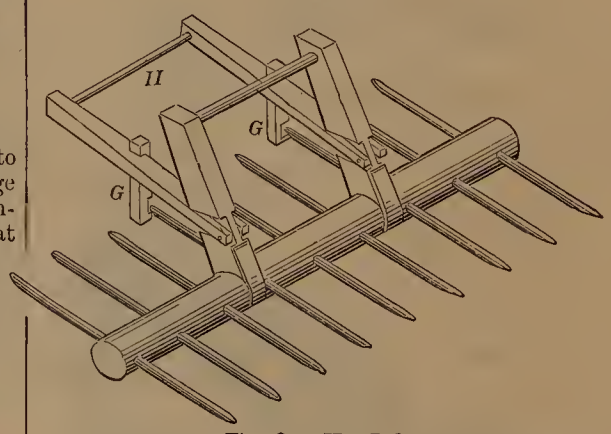
b. An implement drawn by a horse for purpose similar to above.

There are several typical forms : —

1. A series of curved teeth depending from a bar behind an axle supported on wheels. The points of the teeth trail along the ground and gather the hay, which collects in the bend of the teeth. To discharge the collected load, the teeth-bar is rotated on its axis, lifting the points of the teeth, while the clearer bars protruding behind the axle sweep the hay from the teeth. This motion of the teeth is by means of a lever which is conveniently placed for the driver.

2. Another type is that shown in Fig. 2454, in which the rake-head rests on the ground, the front ends being tipped down sufficiently to catch the hay as it lies in the swath. When a load has collected

Fig. 2454.



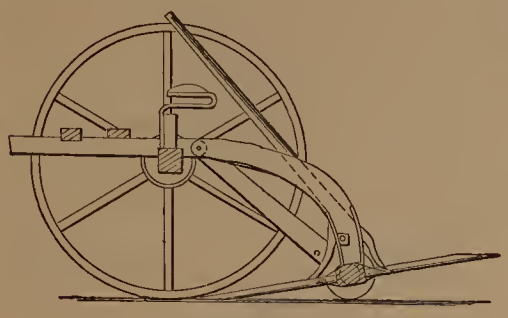
Flop-Over Hay-Rake.

on the rake, the handle *H* is a little raised, causing the front ends of the teeth to catch in the ground and the rake to upset, the dependent catcher *G* slipping from the teeth, to allow the rake-head to rotate. The operator walks behind.

Fig. 2455 shows a substantially similar rake mounted on wheels, so as to allow the person to ride and operate it.

Fig. 2456 is a form in which a frame, carrying a series of rakes on an endless band, trails behind a

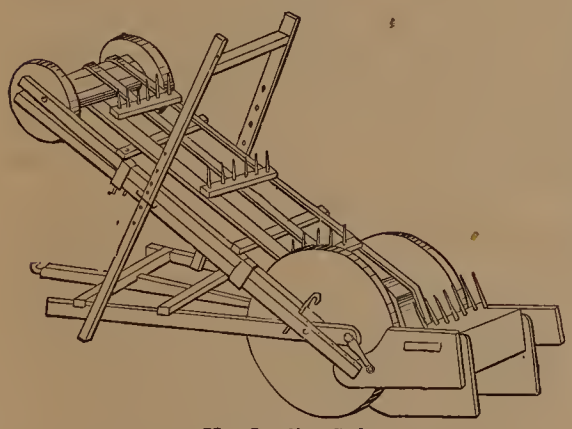
Fig. 2455.



Horse Hay-Rake.

wagon so as to rake up from the swath and discharge it on to the vehicle. After the wagon is loaded the raking-frame is detached and left in the field, or attached to another wagon. See also RAKE.

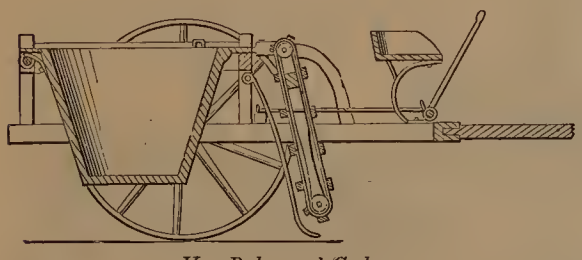
Fig. 2456.



Hay-Loading Rake.

Hay Rak'er and Cock'er. (*Husbandry.*) An implement for raking hay in the swath and cocking it. In the example, the hay is gathered by a rake, carried up by an endless elevator, and received in a

Fig. 2457.



Hay Raker and Cocker.

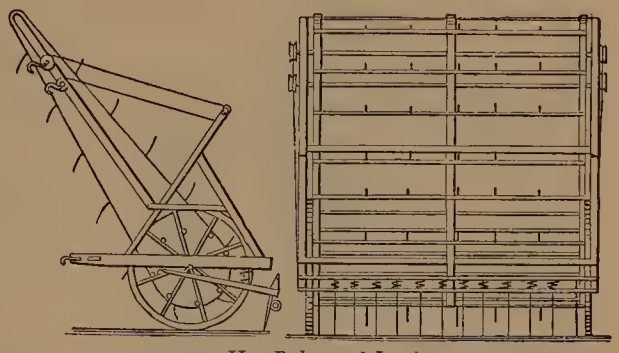
conical receiver which is inverted when filled, leaving the haycock upon the ground.

Hay-rak'er and Load'er. (*Husbandry.*) An implement for raking hay in the swath and delivering it on to a wagon. It is usually attached to the hind axle of the wagon, and is dragged in the rear, a rake gathering up the hay in the swath as the wagon goes over the ground; a traveling apron with teeth lifts the gathered hay, carries it up, and discharges it on to the wagon. When the wagon is loaded the implement is detached.

Hay-spread'er. (*Husbandry.*) A machine for scattering cut hay to expose it to sun and air. A *tedder*. (See Fig. 2460.)

Hay'stack-boil'er. (*Steam.*) A tall form of

Fig. 2458.

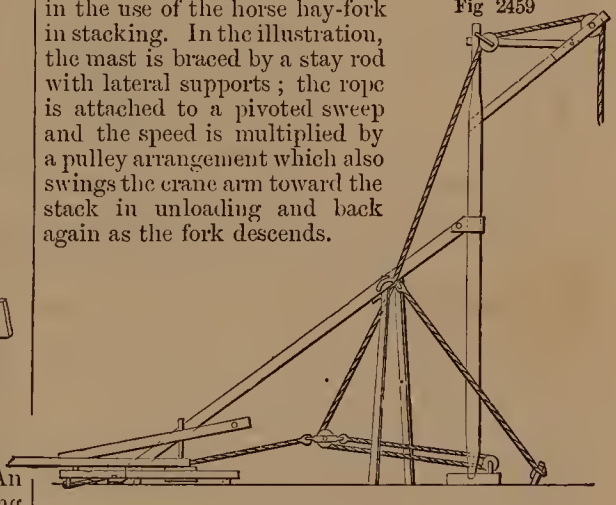


Hay Raker and Loader.

steam-boiler introduced by Smeaton, and shaped like a kettle or a haystack, with flaring sides and rounded top.

Hay-stack'er. (*Husbandry.*) A portable derrick for the suspension of tackle in the use of the horse hay-fork in stacking. In the illustration, the mast is braced by a stay rod with lateral supports; the rope is attached to a pivoted sweep and the speed is multiplied by a pulley arrangement which also swings the crane arm toward the stack in unloading and back again as the fork descends.

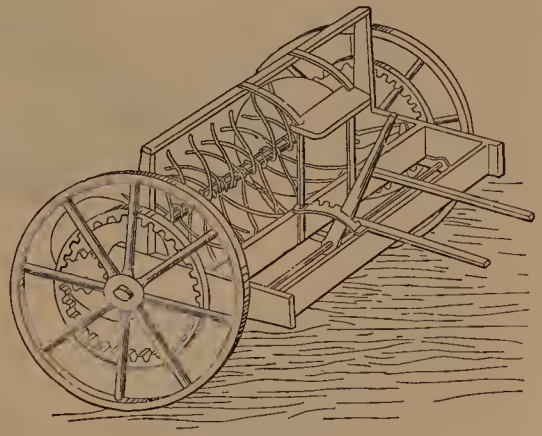
Fig 2459



Hay-Stacker.

Hay-ted'der. (*Husbandry.*) A machine to scatter hay to the sun and air. The hay-tedder was invented about 1800 by Salmon of Woburn, England, and is more useful in the humid climate of that country than in the United States. It consists of a pair of wheels supporting a reel consisting

Fig. 2460.



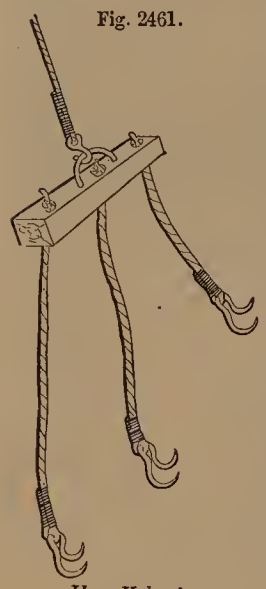
Hay-Tedder

of an open cylindrical frame, formed by arms proceeding from it, and carrying bars set with curved tines, pointing outward. This reel may be lifted

out of operative position when going to and from work in the field, and when at work is rotated by pinion connection to a spur-wheel in the hub of one wheel.

Hay-un-load'er. (*Husbandry.*) A device for bringing the power of a horse to bear in unloading a load of hay in stacking or mowing. The example shows a triple claw which may be made to grasp a bunch of hay, but the horse hay-fork is the usual implement. See FORK.

Fig. 2461.



Hay-Unloader.

Head. The upper end or portion of an object or of a mast, sail, page, column, etc. The other end is the *foot*.

The larger end of a thing, as of a nail, bolt, screw, cane, etc. The other end is the *point* or *tip*.

The effective portion or blade of a tool or weapon, as of a spear, axe, hammer, etc. The other end is the helve, stock, handle, according to circumstances. See HANDLE.

1. (*Machinery, Forging,* etc.) *a.* The striking portion of a hammer, as distinguished from the helve.

b. The *poll* of a hammer, as distinguished from the *claw* or the *peen*, as the case may be.

c. The upper or steel portion of an anvil. The surface is the *face*.

d. That stock of a lathe containing the *live-spindle*. A *poppet*. The other stock is the *tail-stock*, and contains the *dead-spindle*, — as it does not rotate. See LATHE.

2. (*Books*, etc.) *a.* The top of a standing book; sometimes gilded to allow the dust to be blown off. The lower end is the *foot*.

b. The upper end of a page or column.

c. A *sunk-head* is a blank portion at the beginning of a book or chapter.

d. The cross-beam of a printing-press.

3. (*Shipwrighting* and *Nautical.*) *a.* The fore-part, *beak*, or *stem* end of a vessel, the after end being the *stern*.

b. A figure-head, or ornamental device on the prow. According to its character, it is known as a *billet-head*, *bust-head*, *family-head*, *fiddle-head*, *scroll-head*, etc.

c. The upper part of a timber in a frame. The other end is the *heel*.

d. The part of a mast between the *hounds* and the *top*.

e. The forward end of a bowsprit.

f. The top or *drum* of a capstan.

g. The flattish part of a *dead-eye* at the side of the channel or groove.

h. The upper edge of a sail. The lower end is the *foot*.

i. The fore-foot of the keel.

4. (*Carpentry.*) *a.* The top of a *door*, *window*, or *bay*; as a *circular* head.

b. The top-beam or ridge-beam of a bridge or trestle.

c. The square block which slips on the stem of a gage, and carries the scribe.

5. (*Founding.*) The *sprue*, *sullage-piece*, or *riser* on a casting, which is knocked off.

6. (*Mining.*) *a.* The end of *gallery* or *drift*. The *heading* is a passage excavated in the line of an intended tunnel.

b. The top part of a fuse, containing the priming.

7. (*Spinning.*) The system of rollers in a DRAWING-FRAME (which see).

8. (*Hydraulics.*) *a.* The vertical hight or available fall of water from a dam, race, reservoir, standpipe, or forebay; or the difference between the hights of water inside and outside a dock-gate or lock-gate. The vertical pressure usually expressed in pounds.

b. The up-stream end of a canal-lock.

9. (*Architecture.*) The capital (*caput*, head) of a column.

10. The cover of an alembic or still.

11. (*Fortification.*) The salient or advanced portion of a work. A work covering the end of a bridge.

12. (*Coopering.*) That which closes the end of a cask.

13. The *obverse* of a coin or medal. The opposite side is the *reverse*, or *tail*.

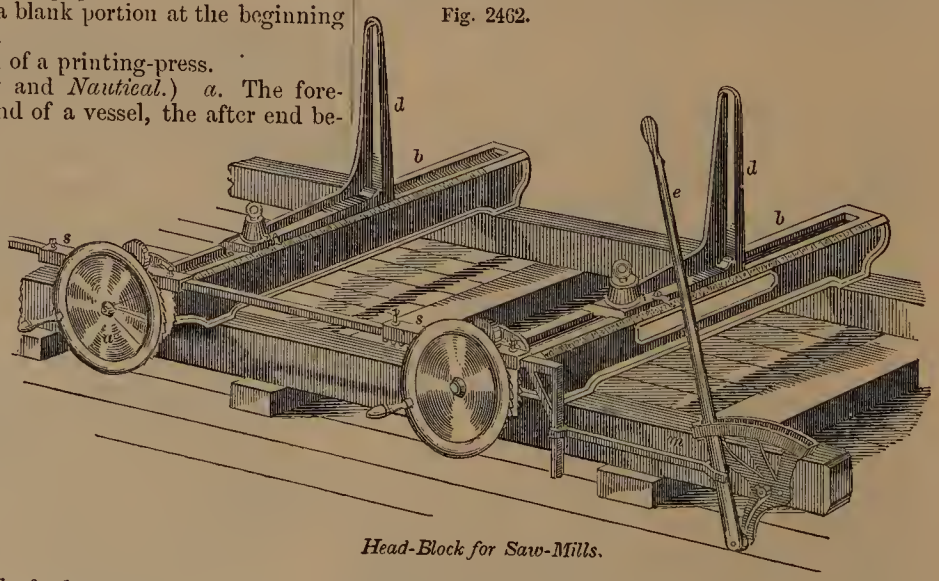
14. The *cap* of a windmill.

Head-band. (*Bookbinding.*) A strip of plaited silk over a mill-board core, or a projecting fillet of fabric which serves as a finish to the top and bottom of the sheets inside the back. It is only used in binding of superior character, as may be seen by comparing a fine calf binding with one in ordinary cloth.

Head-bay. (*Hydraulic Engineering.*) That part of a canal-lock between the upper pond and the head-gates of the lock. See CANAL-LOCK.

Head-block. 1. (*Saw-mill.*) *a.* The block on which the head — or forward end — of a log rests in the ordinary saw-mill; the other end is the tail-block, and they are parts of the carriage on which the log is moved to the saw and gigged back.

Fig. 2462.



Head-Block for Saw-Mills.

b. One of the pieces forming the log-bed in a circular or veneer saw mill. (See CIRCULAR SAW.) In the example the sliding knees *d* form abutments for the log which rests on the head-blocks *b*, and are

moved by screws in the head-blocks. On the ends of the screws are the wheels *a*, which are moved simultaneously by the lever *e*, rod *m*, and racks *s s*.

2. (*Vehicles.*) A piece of wood attached below to the upper ring of the fifth wheel and above to the front spring, also having the front end of the perch mortised through its middle.

Head'er. 1. (*Bricklaying.*) A brick laid with its end or *head* in the face of the wall. It acts as a bond. Bricks laid lengthwise are *stretchers*. See BOND.

2. (*Husbandry.*) A form of reaper. See HEADING-MACHINE.

Head-fast. (*Nautical.*) A rope by which the *head* of a vessel is made fast to a quay or vessel alongside.

Head-gate. (*Hydraulic Engineering.*) *a.* One of the upper pair of gates of a canal-lock. See CANAL-LOCK.

b. A *crown*-gate, *flood*-gate, *water*-gate, by which water is admitted to a race, run, sluice, etc.

Head-gear. (*Harness.*) The bridle of a horse. The head-stall and bit.

Head'ing. 1. (*Mining.*) *a.* The end of a drift or gallery, as "the *heading* is in solid rock and is *driven* by blasting and quarrying."

b. A *gallery*, *drift*, or *adit* in a mine; or in the line of an intended tunnel, especially one of relatively small size, which forms a *gullet* in which the workmen labor, and which is afterwards enlarged by extension sideways and downward to constitute a tunnel.

c. A horizontal passage between the shifts or turns of the working parties.

The illustration shows the headings driven into one of the submarine rocks which render the navi-

Fig 2463.

Headings of Submarine Excavations (East River, N. Y.).

gation of the East River, N. Y., so dangerous. *a* is the shaft; *b*, coffer-dam; *c*, shore line. The headings are all tunnels, and it is the intention to blow up the roof, all the rock to fall back into the cavity.

2. (*Coopering.*) The pieces which compose a cask-head. The central piece is called the *middle*, and the side pieces the *cants*.

3. (*Sewing.*) The extension of a line of ruffling above the line of stitch.

4. (*Fireworks.*) The device of a signal-rocket; such as a *star-heading*, a *bounce-heading*.

5. (*Masonry.*) A course of *headers;* the ends of the stones presented outward.

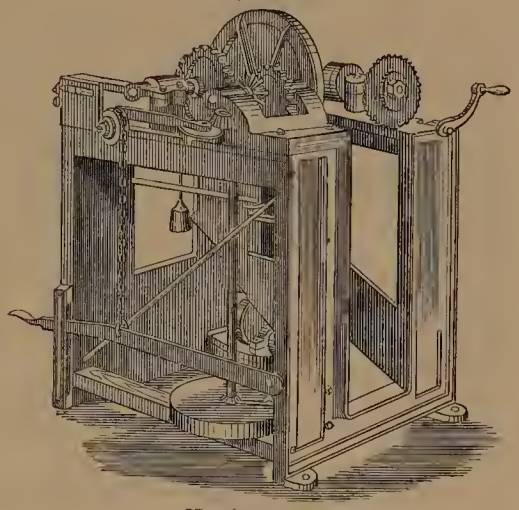
6. (*Books.*) *a.* An inscription at the head of an article, written or printed.

b. A running-title at the top of a page.

Head'ing-chis'el. A chisel for cutting down the head of a mortise. A mortise-chisel.

Head'ing-cir'cler. (*Coopering.*) A machine for cutting down and dressing the pieces to form the head of a cask. The heading stuff is clamped between two disks, trimmed circular by a saw, and dressed by revolving cutters.

Fig. 2464.



Heading-Circler.

Head'ing-course. (*Bricklaying.*) A horizontal course of bricks or masonry in which the pieces are laid with their heads in front; that is, across the thickness of the wall.

Head'ing-joint. 1. (*Joinery.*) A square or butting joint of two pieces, as of sections of hand-railing, floor boards, etc. The junction is secured by dowel, tongue, and groove, or otherwise.

2. (*Masonry.*) The joint between two voussoirs in the same course.

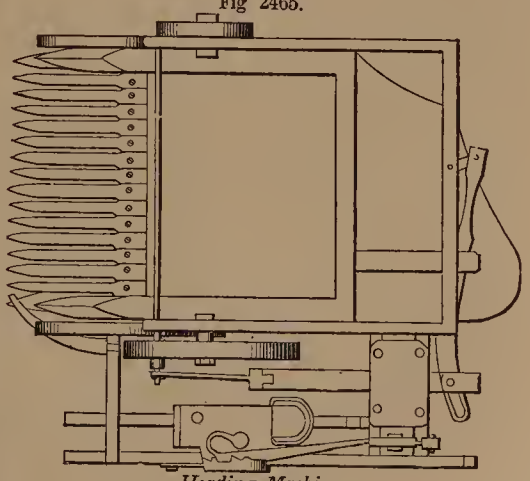
Head'ing-knife. 1. (*Saddlery.*) A round-headed knife used to cut out holes in leather, too large for the application of punches, and smaller than are conveniently made by the *round-knife*, which is the ordinary cutting-tool of the saddler.

2. The currier's knife with one straight and one cross handle, and a turned-over edge. It is used in scraping hides and reducing them to an even thickness. (Fr. *coutcau à revers.*)

3. (*Coopering.*) A knife for cutting the chamfer of the head of a cask.

Head'ing-ma-chine'. 1. (*Agriculture.*) A machine for cutting off the heads of grain in the field, instead of harvesting the whole straw. The machine was tried awhile in Illinois, but its use is believed to have been abandoned except in California. The machine is now always associated with a traveling thrasher, the ripe heads of grain being cut

Fig 2465.



Heading-Machine.

off, thrashed, and bagged. These machines vary in their cutting apparatus; some have the reciprocat-

ing knife usual with reapers, a reel sweeping the heads into a well, from which they are raised by a conveyor to the thrashing-cylinder, and thence pass to the sieves and fan.

Another favorite form is a comb with long teeth of a lance shape; the comb presents its teeth towards the grain, the stalks pass between the teeth, and, reaching the narrow portion, the head is detained and torn off, or is cut off by a revolving brush, a rotating reel, or a traveling belt with scrapers.

The *header* is the oldest form of reaping-machine, and is mentioned by Pliny and Palladius. See REAPER.

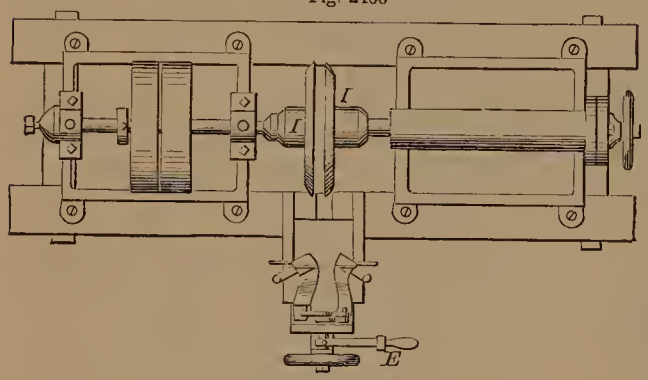
Clover-seed is also harvested in this way, the machine simply tearing off or cutting off the heads. See CLOVER-HEADER.

2. (*Metal-working.*) A machine in which bolt blanks are headed by swaging between dies, or upsetting.

3. A machine for forming the heads of pins.

4. (*Coopering.*) A machine for making heads of casks. The *middle piece* and *cants* are jointed and

Fig. 2466



Heading-Machine.

doweled together and placed between two circular disks *I I*, so arranged upon lathe mandrels that the stock from which the head is to be cut is placed between the heads and clamped by screwing up the loose mandrel; when the heads are revolved, the heading passes between two adjustable arms, having the tools that cut the head to the desired diameter, and bevel the edge at the same time. These arms can be changed to cut heads of greater or less diameter by turning a graduating screw, or they can be expanded to work thicker stuff by oscillating a lever *E* that works a shaft, to which, on the opposite sides, are short levers pivoted to the arms.

Fig. 2467.

Head'ing-tool. (*Forging.*) A tool used in swaging heads on stems of bolts. The rod is run through the hole of the required form and size, and the projecting portion is *upset* or hammered down, forming a knob. This is brought to shape by a swage. A swage with an angle of 60° is used for making hexagonal bolt-heads. (See Fig. 2467.)

Heading-Tools.

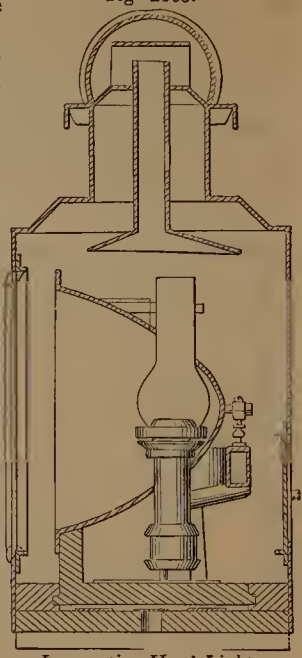
Heading-tools for nail, rivet, and brad forgers are made like nippers to open and release the nail, etc., after the head is swaged down.

Head-knee. (*Shipbuilding.*) A piece of compass-timber fayed edgeways to the stem and cutwater. A *check-knee.*

Head-ledge. (*Shipbuilding.*) One of those portions of the raised rim around the edge of a hatchway which run athwart ship. The parts running fore and aft are *coamings.*

Head-light. (*Railway.*) The light carried at the front end of a locomotive, to illuminate the way and act as a signal. It has usually an oil-lamp, whose flame is in the focus of a parabolic reflector. In the example, the lamp is of the Argand variety, air being admitted to the center and around the tubular wick, while the heated air is received from the chimney by a flue above.

Fig 2468.



Locomotive Head-Light.

Head-line. 1. (*Printing.*) The top line of a page in which the running-title and folio are given.

2. (*Nautical.*) The rope at the head of a sail.

Head-mold'ing. (*Architecture.*) A molding over a door or window.

Head-plate. 1. (*Artillery.*) The plate which covers the breast of the cheeks of a gun-carriage.

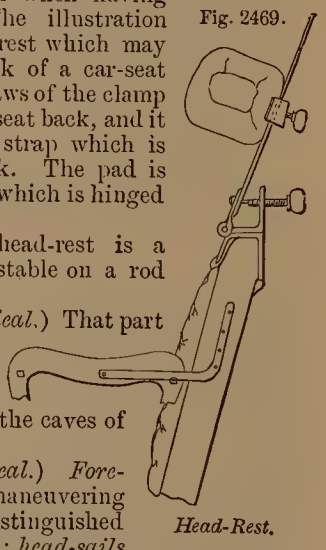
2. (*Saddlery.*) The plate strengthening the point or *cantle* of a saddle-tree.

Head-post. A stanchion by the manger, in a stable.

Head-rail. (*Carpentry.*) The upper rail, or horizontal piece of a door-frame.

Head-rest. A cushion or support against which to place the head in sitting in a car-seat or chair, or when having a portrait taken. The illustration shows a portable head-rest which may be attached to the back of a car-seat when required. The jaws of the clamp embrace the top of the seat back, and it is held in place by a strap which is passed around the back. The pad is adjustable on the bar, which is hinged to the clamp.

Fig. 2469.



Head-Rest.

The photographic head-rest is a cushion vertically adjustable on a rod supported by a tripod.

Head-rope. (*Nautical.*) That part of a bolt-rope sewed to the head of a sail.

Heads. (*Roofing.*) Tiles which are laid at the eaves of a house.

Head-sail. (*Nautical.*) *Foresail.* For purposes of maneuvering ships, the sails are distinguished into *head* and *after* sails; *head-sails* comprehending all sails whose centers lie before the general center of effort of all the sails, and *after*-sails, all whose centers lie abaft that point.

Head-stall. (*Menage.*) *a.* The bridle minus the bit and rein.

b. The halter minus the hitching-strap.

Head-stick. 1. (*Printing.*) A piece of furniture forming the margin at the heads of pages.

2. (*Nautical.*) A short, round stick, with a hole at each end, through which the head-rope of some sails is thrust.

Head-stock. 1. (*Lathe.*) That portion of a lathe which contains the mandrel or *live* spindle on which the work is chucked or to which it is dogged, in contradistinction to the *tail*-stock which contains the *dead* spindle. The *live*-head as distinguished from the *dead*-head.

2. The head which supports the cutters in a planing-machine.

Head-tim'ber. (*Shipwrighting.*) A crooked timber in the frame of a ship's head, to support the gratings. A *bracket*.

Head-valve. (*Steam-engine.*) The delivering valve. The upper air-pump valve.

Head'way. 1. The clear hight of a passage-way, tunnel, gallery, doorway, arch, etc.

2. A gallery at right angles to the main passage-way to the shaft of a coal-mine. A *heading*.

Healds. (*Loom.*) The harness for *shedding* the warp-threads in a loom. The *heddle*. The threads are doubled in pairs, and arranged in sets so as to shift the warp-threads as may be required for plain, twill, or figured weaving.

Heal'ing. (*Roofing.*) The covering a roof with lead, tin, slates, etc.

Heap. 1. (*Printing.*) The pile of wet paper to be fed to, or of printed paper delivered from, a press.

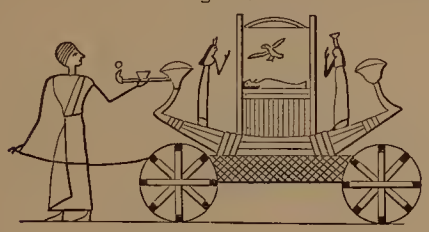
2. (*Mining.*) The refuse or sterile gangue thrown into a pile.

3. The pile of wood stacked for burning into charcoal.

Hear'ing-trum'pet. An acoustic instrument to collect a larger volume of sound and conduct it to the ear. See EAR-TRUMPET.

Hearse. A carriage for the conveyance of dead bodies. In the hearses of the ancient Egyptians we may see traces of the fabled "passage across the lake" which separated the land of life from the land of death, and from which the Greeks derived their Styx and Charon. The legendary custom was to hold an assize at the point where the corpse was embarked, to determine whether the deceased had by

Fig. 2470.



Egyptian Hearse.

his virtues or atonement merited the land of rest. When the determination was favorable, the bier was placed on the boat, which bore his remains to the city of silence. In after times, — as it would seem, — when no lake intervened, the bier or body of the hearse was made to represent a miniature boat, with liliputian rowers, and was mounted on four wheels, or on runners. Instances of both occur in the sepulchral paintings, and the car is shown drawn by oxen or men, and sometimes by both. The Greeks preserved a portion of the legend, turned the practical into the mystical, as usual, in time forgot all about the moral, and degraded the grand assize into a morose old waterman, a great stickler for pennies, and not afraid of ghosts.

Hearses in England are not noticed till the time of James II. Previous to this time, bodies were carried on men's shoulders, on biers, or on horse-litters.

Heart. 1. The interior, as of wood. The solid portion divested of sap-wood or alburnum.

2. The central solid portion or core of a twisted column.

3. (*Nautical.*) *a*. A dead-eye of triangular shape, having but one eye, whose lower edge has *scores* for the lanyard which hauls taut the backstay occupying the outside *groove*.

Fig. 2471.

Collar-hearts are open at the lower ends; a double score is cut round the outside, and two grooves on each side for the seizing, which keeps the collar in the scores of the heart.

b. The inner part of a shroud-laid rope.

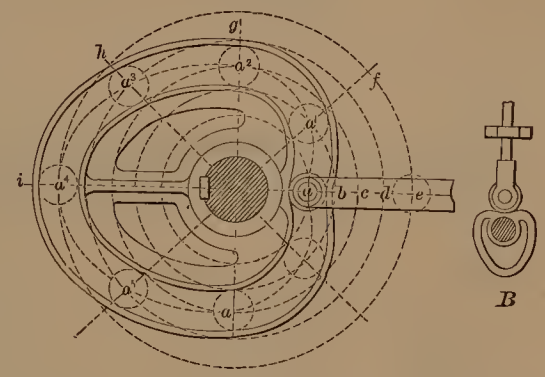
Hearts.

4. A heart-shaped wheel or cam used for converting a rotary into a reciprocating motion. See HEART-CAM.

Heart-bond. (*Masonry.*) A bond in which no header-stone stretches across the wall, but two headers meet in the middle, and their joint is covered by another stone laid *header* fashion.

Heart-cam. A form of cam which serves for the conversion of uniform rotary motion into uniform rectilinear reciprocating motion. The principle of its construction is, that for each successive equal part of one half revolution of the cam, the rod must have been moved by its periphery through a corresponding equal part of the entire stroke. If *a e* represent the stroke required, then divide the same into any number of equal parts, *a* – *b*, *c* – *d*, *d* – *e*, and describe from the center of rotation circles passing

Fig. 2472.



Heart-Cam.

through these points of division; divide half the circumference of these into as many corresponding equal parts, and draw radial lines through the points of division *c f g h i*, then a^1 a^2 a^3 a^4 will represent the successive positions of the point of the rod as the cam revolves, and of course for the return stroke these divisions will recur in the reverse order. To lessen the friction, the rod is provided with a roller, to suit which two equidistant curves are made, forming a groove in which the roller runs.

Hearth. 1. (*Metallurgy.*) The floor in a reverberatory furnace on which ore, metal, etc., is exposed to the action of the flame from the furnace. The hearth has a domed ceiling, and is divided from the furnace by a *bridge*, over which the flame passes. See REVERBERATORY-FURNACE.

2. The floor of a fireplace.

Hearth-brush. (*Domestic.*) A small hair broom for brushing up ashes and tidying around the hearth of an open grate.

Hearth-ends. (*Metallurgy.*) Particles of unreduced lead ore, expelled by decrepitation and the blast from the lead-smelting furnace. This becomes

mixed with lime and fuel used in smelting, and is collected from time to time, is washed to remove earthy particles, and then smelted.

Hearth-plate. (*Metallurgy.*) A cast-iron plate forming the sole of the hearth of a forge or refinery furnace.

Heart-wheel. This is one form of cam-wheel, which acts by a regular impulse and recession to reciprocate the object against which it impinges. (See HEART-CAM.) *B* shows a vertical bar or rod which is raised by the heart-wheel as the point of the heart ascends, and conversely, returning by gravity; keeping constantly in contact with the face of the cam.

Heat. (*Forging.*) *a.* The mass or piece of iron undergoing forging. Where it is made from the end of a rod or bar, the latter is called the *porter*, and forms the handle. When the mass is heavy, a long iron rod is welded to it in continuation of its axis. The mass is then swung from a traversing crane and is guided by the *porter-bar*.

b. A single exposure to the fire, as "to make a weld," or "to shape a horseshoe at a *single heat*."

c. Latent heat "is the heat which is absorbed by bodies in passing from one state to another, but it does not manifest itself by producing an increase of temperature, and is on this account called *latent* heat. . . . . A pound of water at 212° mixed with a pound of *water* at 32° gives two pounds of water at 122°, the mean of the two components; if, however, a pound of *ice* at 32° be mixed with a pound of water at 212°, we have two pounds of water at 51° only, ... the difference being equal to that required to raise two pounds of water through a range of 71° . . . . representing the heat required to liquefy one pound of ice." — BALFOUR STEWART'S *Treatise on Heat*.

It was discovered by Black, and was taught by him in 1762.

d. Specific heat is the quantity of heat required to raise the temperature of a body of a given weight 1°; the unit of measure being the quantity required to raise the same weight of water to the same temperature.

Degrees of heat are noted by the THERMOMETER or the PYROMETER (which see).

In practice the degree is frequently noted as *red* heat, *cherry-red*, *white* heat, *welding* heat, and so on. See FUSING-POINT.

Heat-en'gine. A thermo-dynamic engine in which motive power is produced by the development of heat. Such are steam and hot-air engines, and others which are effective by the explosion of gas, etc. See AIR-ENGINE; STEAM-ENGINE.

Heat'er. 1. A stove or furnace for warming a building, dry-house, or some portion of a machine, as a calendering apparatus in a paper-mill, etc. See list under STOVES AND HEATING-APPLIANCES.

2. A block of iron, made red-hot in a fire, and then placed in an urn or smoothing-iron.

3. A pan in which the juice of sugar-cane, or the water gathered from the maple, receives a preliminary heating before reaching the evaporating-pan.

Heat'ing-ap'pa-ra'tus. See specific list under STOVES AND HEATING APPLIANCES.

The various contrivances employed for warming buildings may be classed under: —

Methods of Warming independently of Ventilation.

1. By close stoves, the heating surface being either of iron, earthenware, or soapstone.

2. By hot-air flues, passing under the floors, or around inside the walls.

3. By a system of endless pipes heated by a current of hot water from a boiler, the circulation being caused by the cooling, and consequently greater weight, of the water in the lower or returning pipe.

4. By steam pipe and radiators.

5. By gas.

Methods of Warming combined with Ventilation.

6. By open fires placed in the several apartments.

7. By causing air, which has been previously heated, to pass through registers into the several rooms.

In the time of Seneca a large stove, or several smaller ones, was constructed in a cellar beneath the living-apartments, and the flue conducted into dining-room and bedchambers. It is probable that the plan resembled some of our green-house arrangements. It was originally used by the Romans in their baths, the *calidarium* being heated by the flues of the fire by which the warm baths were prepared. (See HYPOCAUST.) These caliducts were, no doubt, of various kinds, the architects and engineers of the Imperial City being very skillful and thorough; but it was no doubt true of Italy at that day, as it is at the present, that the provision of means for artificially heating apartments was lamentably deficient. Chimneys were almost unknown. The references to these are very scant and few. See CHIMNEY.

The Italian architect, Palladio, who wrote at A. D. 1560, thus writes of the heating arrangements of the ancient Romans: —

"The Romans were sensible that a continual flame and a great heat from live coals were hurtful to the eyes; they therefore went very wisely about finding out a remedy. They found how dangerous it was to carry fire about the house from one room to another. Stoves are an abominable invention: they cause a continual stench, swell the head, and make men drowsy, dull, and lazy. Most people that use them grow tender and weak: some cannot stir out of these rooms all the winter. The ancients used to light their fire in a small furnace under the earth. Thence they conveyed a great many tubes of different sizes into all the different stories and rooms of the house, which tubes or pipes were invisible, but laid in the thickness of the walls and ceilings, just like water-pipes. Each of these opened at that part of the furnace which joined to the wall of the house, and through these ascended the heat, which was let in whenever they had a mind it should, whether in dining-rooms, bedchambers, or closets, much in the manner as we see the heat or steam of water contained in an alembic to ascend and warm the parts most distant from the fireplace. The heat in that manner used to spread so equally that it warmed the whole house alike. It is not so with chimneys or hearths; for if you stand near, you are scorched; if at any distance, you are frozen; but here a very mild warm air spreads all around, according as the fire that warms the pipes laid along the wall opposite to the hearth is more or less burning. Those pipes which dispensed the heat did not open into the furnace itself, in order that neither smoke nor flame should get into them, but only a warm steam should enter, which they let out again; thereby creating a continual moderate heat. The fire needed not to be large, provided it was continual, to supply those confined and enclosed pipes with a sufficient power of warming. They dressed their meat at the mouth of the furnace; and all along the walls were disposed kettles, or other vessels, filled with hot water to keep the meat warm."

From this it would appear that the conduits were

actually hot-air pipes, and not flues; the heated current in the pipes proceeding from a chamber around the furnace, but not contaminated by the gaseous and sooty results of the combustion of fuel.

In the partially exhumed city of Pompeii there are some traces of the conducting of heat by pipes from the bath-room to the triclinium and other private apartments. Heating by braziers was, however, the ordinary practice when artificial heat was needed, and there are many days in the year when the climate of even Southern Italy is anything but salubrious.

The Chinese call a stove which is heated by a furnace a *kang;* in the *ti-kang* the flue runs under the floor or pavement of the room; the *kao-kang* is used for heating their sleeping and sitting places. In the *tong-kang* the heating flue is carried along the floor, with openings from it at which the heated air and smoke ascend into the spaces of a hollow wall, thus nearly approaching the principle of the chimney.

A *tong-kang* was erected in 1761 by Sir William Chambers for heating the orangery at Kew Palace, near London.

In imitation of the Chinese method, he introduced heated air through an air-pipe or flue in contact with the heating flues.

The method of obtaining warmth in Persia is by means of a large jar, called a *kourcy,* sunk in the earthen floor, generally in the middle of the room. This is filled with wood, dung, or other combustible; and when it is sufficiently charred, the mouth of the vessel is shut in with a square wooden frame, shaped like a low table, and the whole is then covered with a thick wadded quilt, under which the family, ranged around, place their knees to allow the hot vapor to insinuate itself into the folds of their clothing; or, when they desire more warmth, they recline with the quilt drawn up to their chins. The immovable position necessary for receiving the full benefit of the glowing embers is inconvenient; and the effluvia from the fuel is nauseous and deleterious. The *kourcy* also serves for an oven, and the pot is boiled on its embers. This rude and unwholesome method is adopted in the noblest mansions of the cities, as well as in the dwellings of the poorer classes; only, in the former, a more agreeable fuel is burnt, and the ladies sit from morning till night under rich draperies spread over the wooden cover.

The palace of the Khalif of Cordova, A. D. 1000, was heated by hypocausts in the vaults below, the warm and perfumed air being conducted by earthen pipes or caliducts in the walls, and discharged into the apartments.

Heating by a circulation of hot water, proceeding from a boiler and returning thereto in a comparatively cool condition, was invented by Bonnemain in 1777. (See INCUBATOR.) In 1816 a conservatory at Brompton, England, was thus warmed. See CALORIFÈRE; HOT-WATER HEATING-APPARATUS.

James Watt, in 1784, heated his study by a steam box or heater made of sheet-iron, the plates 2½ by 3½ feet and 1 inch apart. This box had an air-escape cock, a steam-induction pipe, and a water-escape. It was supplied by the boiler of the establishment.

The experiment was repeated by a system of copper pipes, under Hoyle's patent, 1791. The steam ascended to the top of the building and passed downward.

Lee of Manchester erected a heating apparatus of cast-iron pipes, which also served as supports for the floor. This was constructed by Boulton and Watt in 1799.

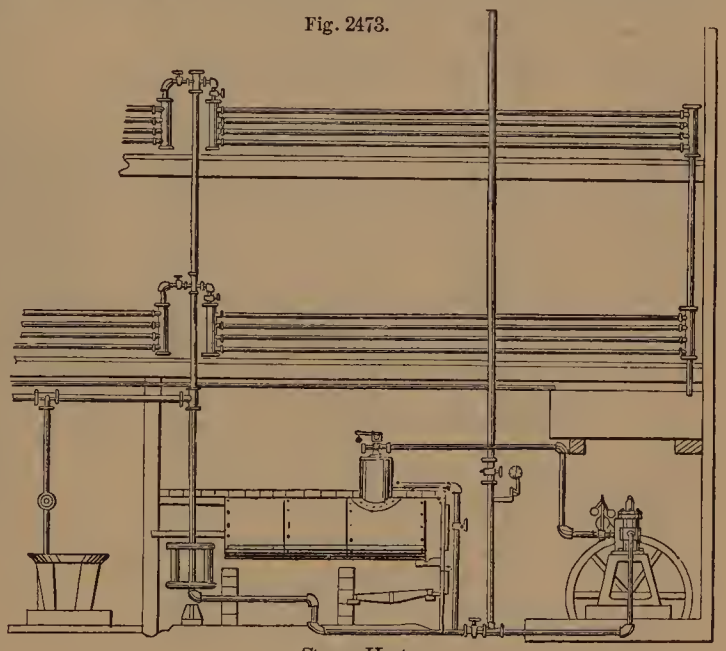
Fig. 2473 shows one form of steam-heating apparatus, in which exhaust steam from the engine is conducted to a heater back of the second fire bridge, and thence by a stand-pipe to the sets of pipes on the different stories of the building.

Gas has been used for warming, sometimes in connection with plates exposed to the jets, and sometimes has been adapted to the ordinary fireplaces where the perforated coil is disposed in a manner resembling grate-bars. Goddard's gas-heater, English, is of the latter description, and asbestus is spread over the bars so as to afford a mass of material capable of preserving incandescence, and affording radiation without consumption.

Warming apartments by hot air, as has been stated, was practiced by the Romans.

The modern mode is by a furnace in the basement story; air from the outside is admitted to a chamber around the furnace and conducted by pipes to the auditorium of the church or to the hall and apartments as the case may be.

Fig. 2473.



Steam-Heater.

The effectiveness of the hot-air current is materially interfered with by the opening of external doors and windows, the circulation depending upon the ascent of the rarefied air.

In the Reform Club House in Pall Mall, London, the circulation is secured by a large fan rotating in a cylindrical case and driven by a steam-engine of 5-horse power in the basement. 11,000 cubic feet of air per minute are forced through a tunnel and then through a cellular steam-heater, where it acquires a temperature of from 75° to 85° Fah. From a brick chamber it passes by pipes to the various apartments, where it is admitted by dialed registers. See HOT-AIR FURNACE; VENTILATION.

Dr. Arnott calculated the quantity of heat-radiating surface necessary to warm a room in winter to 60° when the external temperature is 22°, to be a foot square of surface heated to 200° for every six

feet of glass, as much for every 120 square feet of wall or ceiling, and as much also for every six cubic feet of air escaping per minute by ventilation. See GRATE; FIREPLACE.

Heat'ing-pan. 1. A flat pan with stirrers, in which linseed meal is warmed before being bagged and pressed.

2. The first pan into which sugar-water of the maple, or the juice of the sugar-cane, is warmed before dipping or running into the evaporator.

Heat'ing-stove. The stove of Russia, Poland, and Northern Germany consists of a combustion-chamber and a number of reverting flues in which the heated current gradually parts with its caloric. The fire-chamber is surrounded by a good non-conductor of heat, and the heated products of combustion are retained within the stove as long as possible, in order to communicate the greater part of their heat to the stove, and thence to the air of the room.

This is effected by an arrangement similar to that shown at *A* (Fig. 2474), in which the lower space represents the fire-chamber, at the back of which is an upward passage *b* for the flame and smoke, which are successively diverted on their upward course by the partitions *d c f g c*, passing through their openings until discharged through the opening *h*, which is controlled by a damper.

These stoves are mounted on pillars, are made narrower toward the top, and are not placed in contact with the wall, so as to expose their whole heated surface.

In other cases they are built within partition walls, so as to heat two apartments at the same time. The fronts of these stoves are frequently quite ornamental, being built up into several stories of white porcelain in tasteful designs, and having polished brass doors.

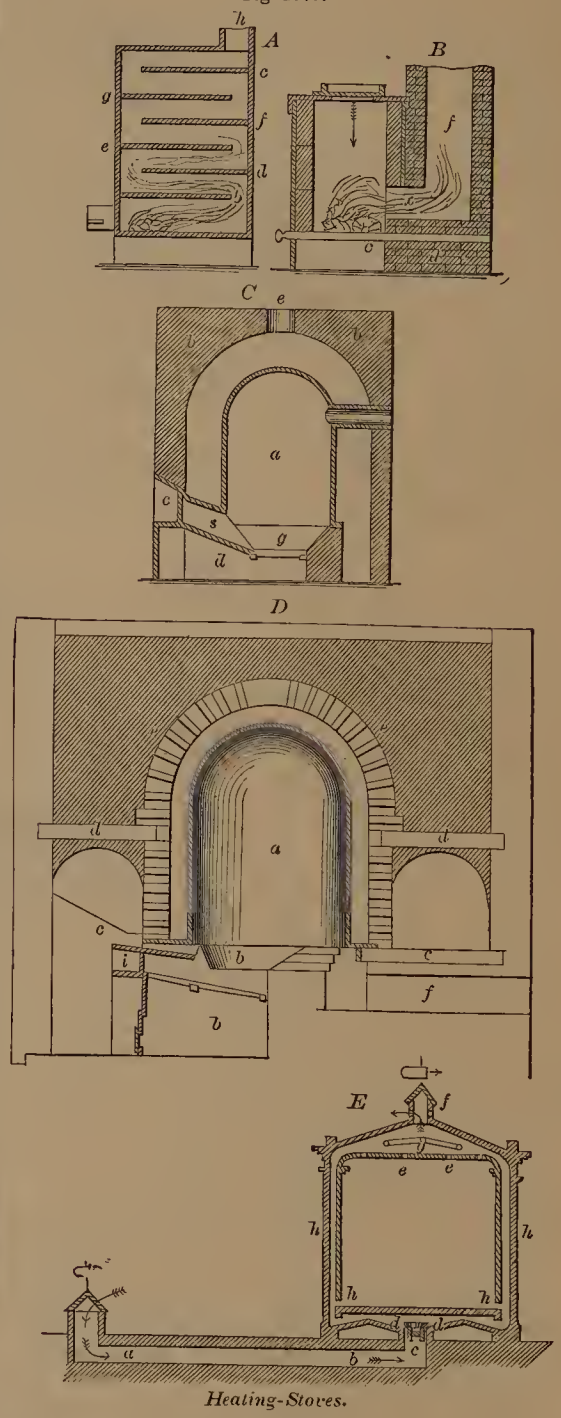
Beaumont's English stove (*B*) acts by a downward current. Two iron plates *c* are laid upon the foundation *d*, and between them is a sliding plate which covers the ash-pit. They are surmounted by a drum lined with firebrick and having a flue *x*. The drum is covered with a circular plate of cast-iron, having an opening for the admission of fuel and covered by a lid, pivoted to serve as a register. On lighting the fire this is slightly opened, and though the smoke at first tends to rise that way, the heat soon determines a downward current which deflects it through the flue *x* into the chimney *f*.

The Cockle stove *C* (Ger. *Kachel*, a tile; *Kachel-ofen*, a tile-stove), as made by Strutt, of Derby, England, has a cylindrical iron fire-chamber *a* with flat or dome-shaped head, around which is built, leaving a certain interval, a structure *b b* of brick.

The fuel is fed at *c*, sliding down the inclined plate *s* to the grate *g*. *d* is the ash-pit and draft-hole. The heated air between the stove and its casing is admitted into the room through one or more apertures *c*. This is also known as the "Belpre" stove, as the cotton-factories of the inventor in that town were warmed by it in 1792.

D is a stove erected by Sylvester for the Derby infirmary, on this principle. *c c* are the openings leading from the exterior of the building and supplying fresh air. The *cockle a* is cubical in form, and has a groined arch dome. It is made of iron plates riveted together. The smoke passes off by a narrow passage at the base of the cockle through the flue *f*. The brickwork surrounding the cockle is built with alternate openings between the bricks. Through these apertures are inserted pipes of sheet-iron, or porcelain, so as to extend within an inch of the cockle, by which means the air to be heated may be thrown near, or in immediate contact, with the surface of the cockle, if desirable. The horizontal partition *d d* cuts off the communication between the lower and the upper portion of the air-chamber, the arched openings in the lower half *c c* being the openings of the main air-flue leading from the exterior atmosphere. The fire-room

Fig. 2474.

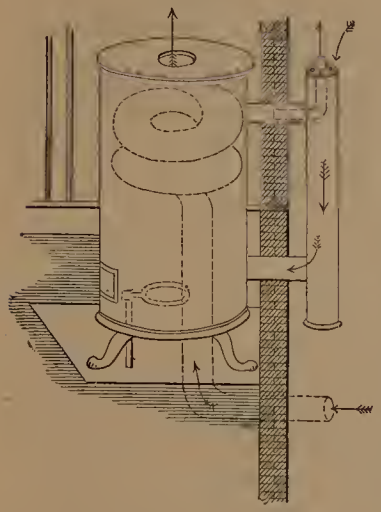


and ash-pit are shown at *b b*, and the fuel is introduced by the opening at *i*.

The air passing from the lower flues *c c* through the apertures beneath the horizontal partition, and coming in immediate contact with the surface of the cockle, finds its way into the upper air-chamber *c e* through the numerous pipes or openings of the upper division, by which circuit its velocity will be sufficiently retarded to obtain the necessary elevation of temperature from the heated cockle.

In the plan submitted by Sylvester, 1835, for warming and ventilating the Houses of Parliament (*E*, Fig. 2474), the fresh air was to be admitted through an underground channel *a b* to a cockle *e* beneath the floor of the building. It is thus heated about 15° in winter or cooled a like amount in summer. On passing through the cockle it spreads into the open space *d d*, and thence is distributed to all parts of the chamber through apertures in the floor. The ascending vitiated air, passing through openings *e e* in the ceiling, is discharged through the turn cap *f*, the opening of which is always opposite the wind. Heated pipes *g* near the roof were to insure a sufficient upward draft. When necessary to obtain a greater heat the apertures in the ceiling are closed, and the air escapes through openings in the walls *h*.

Fig. 2475.



Gas Heating-Stove.

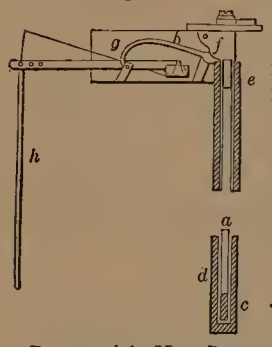
Fig. 2475 is a gas-heater. The cold air entering through the bottom is heated during its passage through the coil by annular gas-jets, and discharged into the room through the opening above. The products of combustion within the smaller drum are partly discharged through a small upward pipe, and the rest, in conjunction with a small quantity of cold air admitted through the apertures above the drum, is reverted, passing downward to aid in keeping the larger drum warm.

Heat'ing-sur'face. (*Steam-engineering.*) The fire-surface or amount of surface exposed on one side to fire and the other to water. The allowance is from 11 to 18 square feet per horse-power.

Heat'ing-tube. (*Steam.*) A water-tube in a steam-boiler surrounded by flame and connecting at each end with a water-space.

Heat-reg'u-la'tor. A device invented by Bonnemain, to keep up an equable heat in his INCUBATOR (which see). An iron rod *a* is tapped at its lower end into a brass nut *e*, inclosed in a leaden box *d*, terminated above by a brass collet *e*. The greater expansibility of the lead causes it, when the heat rises to the desired point, to elevate the collet *e*, which presses against the shorter arm of the bent lever *f g*, to the longer arm of which is connected a rod *h*, and serves to open or close a register that admits air to the fire. The instrument is provided with a dial graduated to indicate if there is an excess or deficiency of heat. See THERMOSTAT.

Fig. 2476.



Bonnemain's Heat-Regulator.

Heave. (*Nautical.*) *a.* To careen a vessel and expose the hull below the water-line, for the purpose of cleaning or repair. Known as *heaving-down* or *heeling*.

b. To haul on a rope or cable.

c. To cast the lead in sounding.

The term is frequently compounded; as, —

To *heave in stays;* to bring a ship's head to the wind. To *heave down*, to careen.

To *heave astern;* to draw the vessel aft.

To *heave and set;* to ride hard.

To *heave short;* to bring the ship above the anchor.

Heav'er. (*Nautical.*) A handspike.

Heck. 1. (*Weaving.*) A device through which the yarns pass from the warping-mill to the reel on which they are wound in order for transference to the warp-beam of the loom. The *heck-box* slides vertically on a bar as the reel rotates, and thus disposes the warp spirally on the reel.

The *heck* consists of a series of steel pins with eyes, through each of which one thread passes. The *heck* is in two parts, one a little raised from the other. The eyes of the parts being alternate, by raising one of them a little, the *bands* of the warp are separated; when the other part of the *heck* is raised, the position is reversed, the former upper band becoming the lower. This produces the *lease*, which is tied up, to form a guide for setting in the loom.

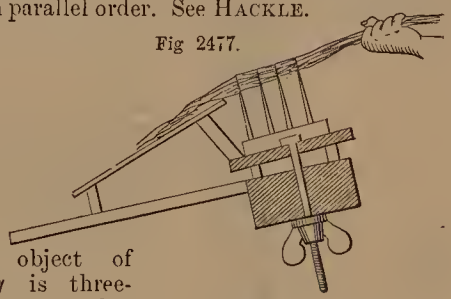
2. The *fly* of a spinning-wheel.

3. A fish-trap.

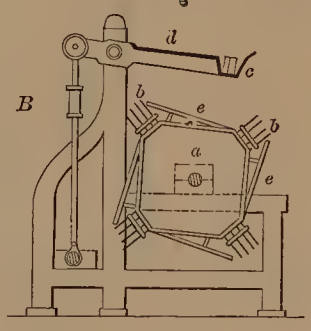
Heck-box. (*Weaving.*) A box suspended between the *travers* on which the bobbins of warp yarn are mounted, and the warping-frame on which the yarns are wound. Its duty is to divide the warp threads into two alternate sets or *leas*, one set for each *heald* or *heddle*. Also called a *jack*. See WARPING-MILL.

Heck'le. A board with sharp steel wires over which flax or hemp is combed, to clean, split, and arrange the fibers in parallel order. See HACKLE.

Fig 2477.



The object of *heckling* is threefold: first, to disentangle and straighten the fibers; secondly, to split the wider ribbons, to lessen them and equalize their size; and, thirdly, to remove the shorter stuff from the longer, the *tow* from the *line*.



Heckle.

Heckles are of various grades of fineness, but the finer have shorter and more slender teeth; the grades are known as the *ruffer*, *common* 8, *fine* 8, 10, 12, 18; in allusion to the number of pins in a row. The pins are driven through a tin-covered board, which is clamped to the bench in a backwardly slanting position, as shown in the illustration. The bunch of flax, known as a *strick*, is thrown upon the *heckle* and drawn towards the operator, a sloping board at the back preventing its penetrating too far. One end being dressed, the *strick* is reversed in the hands of the operator, and the other end is *heckled*.

From 100 pounds of well-cleaned flax, 45 to 50 pounds of *heckled line* are obtained by hand labor of twelve hours.

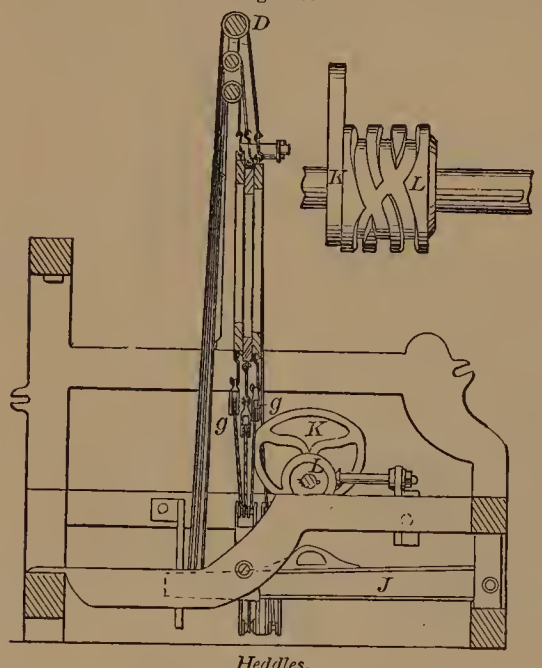
Heck'ling-ma-chine'. A machine for *heckling*, that is, separating the fibers of flax. The illustration (*B*, Fig. 2477) shows one of the earliest forms, designed to imitate the process of hand-heckling. It consists of a rotating square *a* with truncated corners, at which the heckles *b* are fixed. A *strick*, about four ounces of flax, previously slightly straightened and dressed, is fixed in the holder *c* on the arm *d*, which is oscillated while the heckle-carrier is being rotated. The separated fibers which collect on the heckles are removed by hand, and the strick, when thoroughly heckled on this, is again heckled on a similar machine with finer teeth. *e e* are back-boards limiting the depth of penetration.

A machine in which the strick of flax was made to vibrate over fixed teeth, so as to heckle the two sides at once, has also been employed.

Machines in which the strick was held over an endless band provided with heckle teeth, or drawn between two such bands, have been used to a considerable extent. The machine now in general use consists of an exterior drum, at the periphery of which are placed removable holders; this has a slow rotary motion, while rapid revolution is imparted to a toothed drum within; the flax hanging down from the holders is, when sufficiently heckled on one side by these teeth, removed, turned, and heckled on the other side.

Hed'dle. (*Weaving.*) One of the sets of parallel knotted cords forming loops for the warp-

Fig. 2478.



Heddles.

threads; and by whose vertical reciprocation the warp-threads are shifted so as to make the *shed* for the passage of the shuttle. The heddles, with their appliances for moving, constitute the harness. See HARNESS.

Heddles are a necessary integral feature of all looms, having sets of strings for separating the warp-threads into two or three groups, between which the weft is passed. This is called *mounting the loom*, and consists in dividing the warp among the *leaves of healds* or *heddles*.

In *plain weaving* but two heddles are required, which raise and depress alternate threads; but in twills the *heddles* are equal in number to the number of threads contained in the interval between two intersections of the warp and weft. In *blanket twill* every third thread is crossed. In finer fabrics the threads intersect each other at intervals of 4, 5, 6, 7, or 8 threads. In full satin twill there is an interval of 15 threads. With the Jacquard the devices rise to the highest order of merit. See JACQUARD.

In the illustration, the twilling-cam *K* depresses such one of the set of levers *J* as is beneath it for the time being. The cam *K* is attached to a circumferentially grooved hub L, which slides on the shaft *y* and is controlled in its motions by a switch, so that the motions of the heddles *g g* follow in proper sequence. The heddles are suspended by cords which pass over a roller *D* and down to the levers.

Hed'dle-eye. (*Weaving.*) The loop in a heddle through which the warp-thread is passed.

A glass ring in the eye is known as the *mail of the heddle*.

Hed'dle-hook. (*Weaving.*) A hook used in heddling the warp-threads.

Hed'dling. (*Weaving.*) Drawing the warp-threads through the *healds* or *heddles;* a weaver's harness.

Hedge-bill. (*Husbandry.*) A cutting-tool used in making stakes for repairing and for trimming hedges. See BILL-HOOK.

Hedge-clip'per. (*Husbandry.*) A favorite device for dividing land into fields, especially where lumber and stone are scarce. For obvious reasons, the thorn has always been a favorite for this purpose; Micah (vii. 4) says, "Sharper than a thorn hedge." It is yet the ordinary fence in Palestine.

The relevancy of the subject here arises from the fact that tools and machines are made for planting, training, and trimming hedges.

Thorns for hedges were used by the Greeks 1000 B. C. Homer represents Ulysses as finding Laertes digging, and preparing to plant a row of quick-sets.

"The art of clipping trees," says Pliny, "was invented by C. Martius, a friend of the late Emperor Augustus, within the last eighty years" (A. D. 79). He had not seen the beautiful gardens of Egypt.

In some of the principal apple counties of England, the hedges are made of apple and pear trees trimmed to the proper proportions. In Brecknockshire, hazel is much used; blackthorn and hawthorn are also common; the latter is more used than any other hedge shrub.

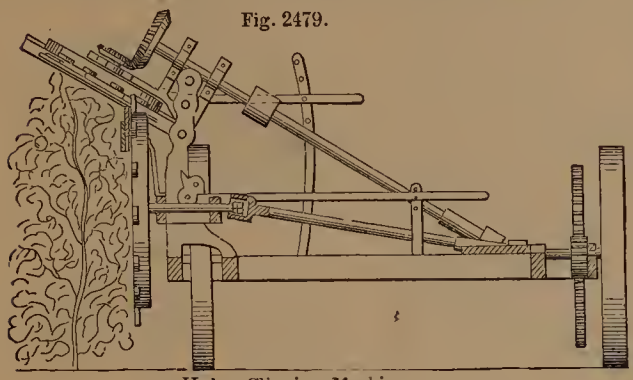
The osage-orange (*Maclura*), honey-locust, and some varieties of thorn, are used in the United States for hedges. Hawthorn is the favorite in England, but does not stand our climate. Ornamental hedges are made in this country of privet, althea, spruce, arbor vitæ, rose, and occasionally a pear or other trees and shrubs. In England, the laurel, laurustinus, arbutus, Portugal laurel, bay, and other beautiful evergreens are used, but they do not so well suit this climate.

Hedges are planted in single or double rows, the latter from eight to twelve inches apart. The plants about the same, except that in single row they are at a distance of six inches. The maclura or osage-orange is the favorite, and has a great tendency to run up. It must be clipped savagely to make it spread below, allowing it an extra three inches of hight at each of the three clippings during its first year's growth. In succeeding years it may be allowed to advance about a foot a year, and at the end

of five years it should be five feet broad at bottom and five feet high, slanted on each side to a central ridge. A first-rate fence is horse-high, pig-tight, and bull-strong.

Planted in a single row, six inches apart, a mile of hedge will take 10,560 plants. A double row — the plants eight inches apart in the rows — will take 15,840 plants. A fence eight rails high, staked and double-ridered, will, for the same distance, take 7,680 rails. Board fence, five boards high and the posts six

Fig. 2479.



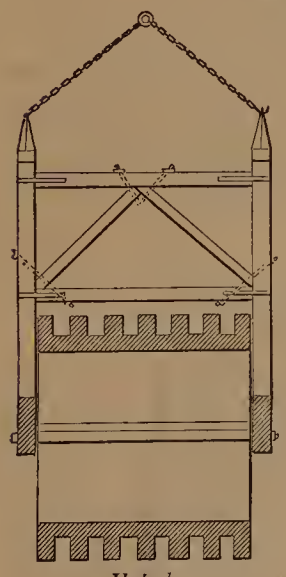
Hedge-Clipping Machine.

feet apart, will take 1,173 posts and 13,200 feet of lumber, the boards being six inches wide and one inch thick. To this latter calculation add the value of the nails; and in each mode of fencing consider the first cost of putting in order and the subsequent wear and tear, and the cost of renewal of the rail and board fences, and of clipping the hedges.

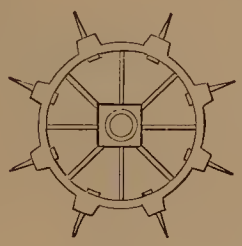
Hedge-clipping tools are usually shears (see HEDGE-SHEARS); but machines are made which pass alongside the hedge and, by their revolving cutters, trim it to the shape to which the cutting apparatus is adjusted, as in Fig. 2479.

Hedge'hog. (*Hydraulic Engineering.*) A machine attached to the stern of a steamboat or barge,

Fig. 2480.



Hedgehog.



and dragged along the bottom of a river or watercourse to remove the mud or accumulation on the land side of a sluice, by raising and disturbing the mud and silt so that the current will carry it off. It consists of a frame with a revolving reel armed with shovels, which dig into the mud and spade it up as it is dragged along.

The frame is of 4 × 6 oak scantling, braced, and diagonally bolted. The spades are 4 inches wide, 7 inches long, and 7 inches apart. In some cases it is hauled by capstan and tackle, or moved by the current.

Hedge-plan'ter. (*Husbandry.*) A frame for holding plants in order as to distance and position while being set in the furrow prepared for them. The plants are clamped and supported at their

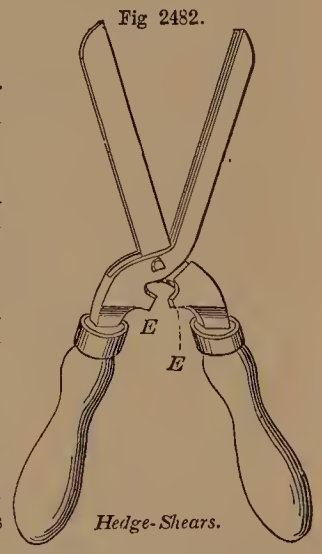
Fig. 2481.

Hedge-Planter.

proper relative distance between adjustable bars which engage perforated plates in the posts.

Hedge-shears. (*Husbandry.*) A large scissors for trimming the rampant growth of hedges. In the example, the blades are for the shearing action, and a more powerful cutter *E E* is provided for stray stalks.

Fig 2482.



Hedge-Shears.

Hedg'ing-tools. (*Husbandry.*) The implements for hedging are thus enumerated by English authority. The items may be useful.

A scuffle hoe; blade 7 inches long, handle 5 feet long.

A hedging spade 3¼ feet long, blade 6 inches wide.

A hooked cutting-tool; blade 9 inches long, 1½ inches broad; shaft 2¼ feet long; weight, 2¼ pounds.

A heavier bill-hook for cutting stems; blade 7

Fig. 2483.

Hedging-Tools.

inches long, 2½ inches broad; handle 2½ feet long. Tool weighs 6 pounds.

A light axe weighing 3 pounds; helve 3 feet long.

Heel. A term as opposed to *toe*.

1. (*Shoemaking.*) A block built up of pieces of leather, and serving to elevate from the ground the rear portions of the boot or shoe.

Heels are usually made of several thicknesses of leather, called *lifts* or *taps*, which are fastened together and to the *insole* and *quarter* by pegs or nails.

Other materials are used for heels, such as, —

Wood.	Cast-iron.
Vulcanite.	Metal. Plated

Brass shells filled with wood.

Shell of leather, filled with composition of sawdust, waste-leather scraps, and glue or resin.

Pieced heels are made of scraps approximately fitted together in a mold having movable sides, and then compressed so as to bring them to close conjunction and the required form. See Bigelow's patent, in which the *blank-heels*, built up in readiness for attachment to the boot, are punched while in a state of compression, and have the nails partially inserted ready for the final driving which fastens them to the boot. In some cases, as a substitute for the shaved *rand*, the upper lift is made basin-shaped by compression. The punching is done by a gang of awls. See also Ellis's patent of December, 1863, reissued, for punching the lifts of boots and shoes.

After the blank-heel has been made, it is placed in the socket of a machine against the boot in position, and a plunger drives the whole gang of nails at once through the insole and counter, and clenches them against the anvil which rests on the insole of the boot. Or, nails are forced through the inner sole into the heel from within; also, from the outer or wearing surface down through the heel-lifts by means of rods arranged to pass through nail-plates.

Julius Cæsar wore high-heeled shoes to increase his apparent stature. The shoe covered the foot.

2. A term as opposed to *head*.

(*Nautical.*) *a.* The after end of a ship's keel.

b. The lower end of a spar or timber, as the heel of a *mast*, of a *boom*, of the *bowsprit*, of the *sternpost*, of the rudder, of a *shore*, of a spar when used as a *jib* or *shear-pole*, etc.

c. The lower end of a timber in a frame; the other end is the *head*.

(*Carpentry.*) The lower end or foot of a *rafter* where it rests on the wall or plate.

(*Fire-arms.*) The upper end of the butt-end of a musket when in firing position.

The tail of a gun-lock hammer.

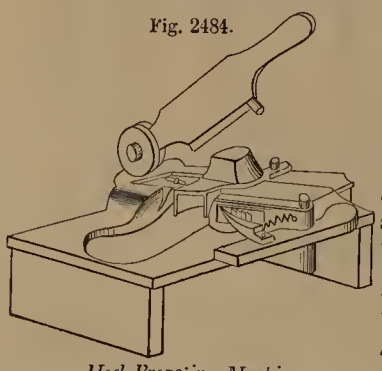
3. A lean or inclination.

(*Nautical.*) *a.* The inclination laterally of a vessel as she careens under a press of sail. Allowance for the heel is made in laying guns, a pendulum being used for the purpose.

In careening the "Royal George," 120 guns, at Spithead, 1782, to get at a water-pipe which discharged below the water-line, the vessel was sunk at her moorings.

"They made the vessel heel
And laid her on her side."

Fig. 2484.



Heel-Breasting Machine.

b. Said of a ship when deep in the water aft. *By the heel*, in contradistinction to *by the head*.

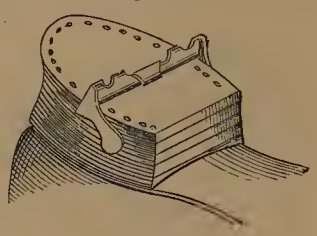
Heel-blank. (*Shoemaking.*) A set of *lifts* fastened together in readiness for attachment to a boot. A *blank heel*.

Heel-breast'ing Ma-chine'. A machine for cutting down the straight front face of a boot or shoe heel, as in the example, which has two adjustable jaws as a means of holding the heel, and a cutter and gage-plate combined with the said jaws, and a lever with pawl and rack operating on one of the jaws.

Heel-bur'nish-ing Ma-chine'. See HEEL-POLISHING MACHINE; BURNISHING-MACHINE.

Heel-calk. (*Shoemaking.*) A roughing for a heel, to prevent the slipping of the wearer on ice or slippery pavement. In the example, it consists of a strip of metal fastened to a heel by making two holes on either side of the heel. It is armed with points, and easily removable on account of its elasticity.

Fig. 2485.

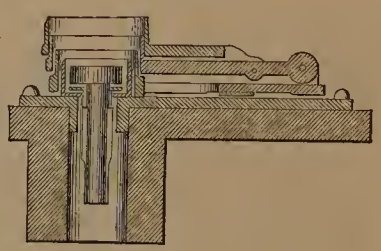


Heel-Calk.

Heel-chain. (*Nautical.*) A chain for holding out the jib-boom.

Heel-cut'ter. (*Shoemaking.*) One for cutting out the lifts which form the heel. In the example, the cutters are various in size, and are hinged to the frame, so that they can be let down over each other. The heel-lifts are cut to graduated size, and merely require beveling after attachment. The leather is placed on the cutters and forced down by blows of a wooden mallet.

Fig. 2486.



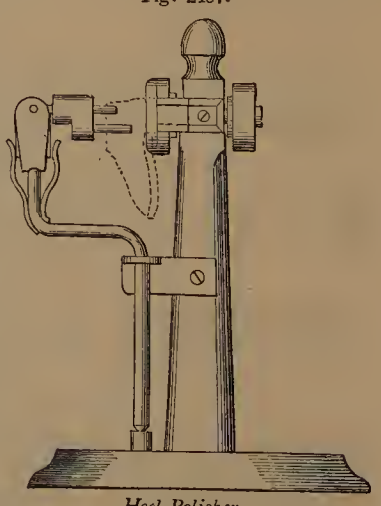
Boot-Heel Cutter.

Heel-face Dress'er. (*Shoemaking.*) One for rasping and dressing off the lower face of the heel. The boot is held by a clamp, the guides of which enter the rand, and so hold it parallel to the rotary disk-wheel which trues the face, and a burnishing-wheel which polishes the side.

Heel-i'ron. (*Shoemaking.*) A plate on the lower surface of a boot or shoe heel, to increase the durability. Sometimes put on to make a clattering, as in some fancy dances, perhaps the *cracovienne*.

Heel-ma-chine'. (*Shoemaking.*) The series of machines for this purpose are for cutting out *lifts*, or making them up of pieces and compressing them to shape; building up blank-heels by fastening together in proper order as to size the several lifts of which a heel is composed; trimming or burnishing the heels to give the required curve; *breasting*, that is, cutting down the front; cutting the seat for the heel; laying on and securing the *rands*; fastening the heels

Fig. 2487.



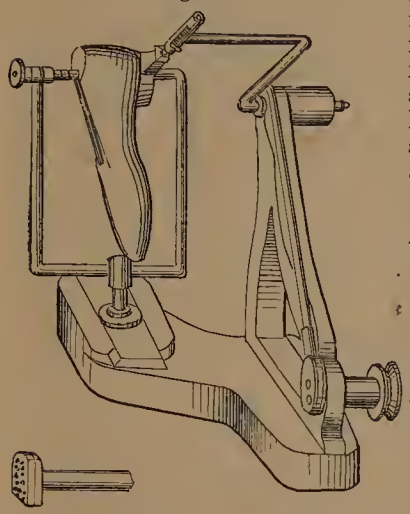
Heel-Polisher.

to the boots; dressing the heel-faces; polishing the heels; giving the stitch-marks on the upper surface along the edge. These operations are usually done by separate machines, and with great rapidity.

Heel-plate. The plate on the butt-end of a gun-stock.

Heel-pol'ish-ing Ma-chine'. (*Shoemaking.*) One for smoothing the surface of a heel after it is shaped and trimmed. There are several modes.

Fig 2488.



Reciprocating Burnisher-Machine.

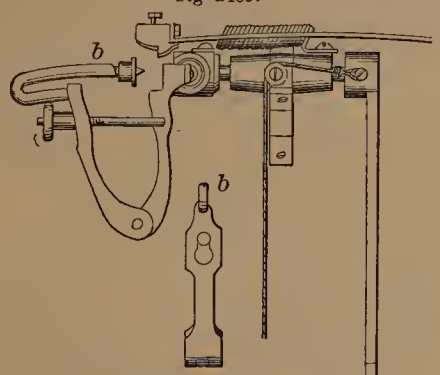
1. In the Ellis and Glidden machine, trimming and burnishing devices, actuated by a lever, move around the surface of the heel, guided by a plate having the form of the finished heel.

2. The boot is jacked and is revolved against a rotating burnisher, as in Fig. 2487.

3. The boot is clamped to the sliding frame, and the polisher reciprocated over the surface of the heel by an eccentric, whose rod is connected to the oscillating arm. (Fig. 2488.)

4. The boot is jacked, the arm *b* (Fig. 2489) reaching down the boot-leg and holding the heel to its seat. The heel is held up to the polisher, and the edge of the heel against the polisher-flange, which prevents the outer lift from spreading away at its

Fig 2489.



Stationary Burnisher-Machine.

edge while the jack is being rocked to bring the whole edge of the heel under the action of the stationary polisher.

Heel-post. 1. (*Shipbuilding.*) The post which supports the outer end of a propeller shaft.

2. That stile of a gate to which the hinges are attached.

3. The post to which a gate or door is hung.

4. The quoin-post of a lock-gate.

Heel-ring. (*Husbandry.*) The ring which is tightened by wedges and confines the scythe-blade to the snath.

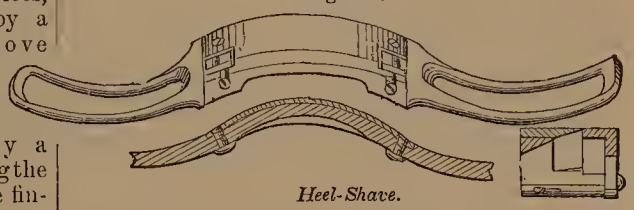
Heel-rope. (*Nautical.*) A rope for hauling on the heel of the bowsprit to run it out.

Heel-seat Cut'ter. (*Shoemaking.*) One employed to cut out the concavity in the heel to fit upon the convexity caused by the filling piece of the shank. The invention combines with a reciprocating gouge-like shank means for relative adjustment between the knife and heel-holder, adapting the same machine to cut heel-seats to fit upon different shanks.

Heel-shave. (*Shoemaking.*) A hand-tool like a *spoke-shave*, to shape the heel after the lifts of approximate shape have been fastened together.

The attaching screws of the curved blade pass

Fig. 2490.



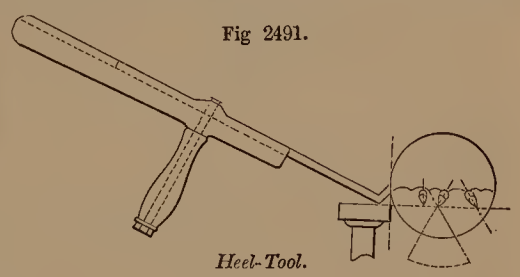
Heel-Shave.

through slots in the bridge-piece and allow adjustment of the blade. The guard-piece is removable, to admit sharpening of the blade.

Heel-tap. (*Shoemaking.*) One of the pieces or thicknesses of leather of which a heel is built. A *lift.*

Heel-tool. (*Metal-turning.*) A form of metal-turning tool in which the *heel* of the tool is supported on the rest. The helve has one piece which

Fig 2491.

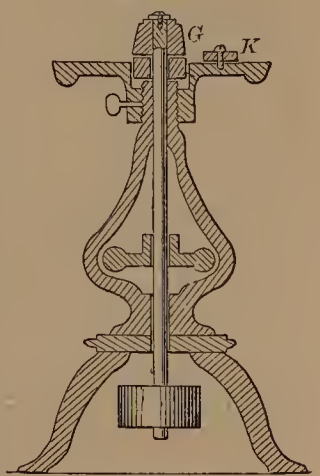


Heel-Tool.

rests on the shoulder, and a handle whereby the cutting edge is adjusted as to presentation to the work.

Heel-trim'mer. (*Shoemaking.*) *a.* A machine in which the edges of the lifts are pared down so as to bring the heel to symmetrical shape. In the example, the collar limits the depth of cut made by the bur. The adjustable table board adapts the bur cutter to the varying depths of the boot-heels, and the stud or roller steadies and supports the heel while being trimmed. The shape of the rotary cutter *G* determines the contour of the heel, which is oscillated on the roller *K* to bring each part of its surface to the cutter.

Fig 2492.

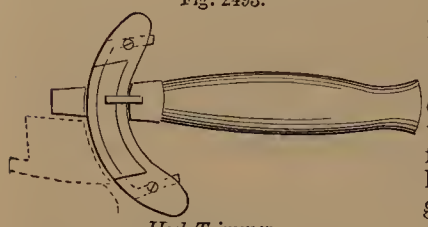


Heel-Trimming Machine.

See also HEEL-POLISHING MACHINES, which differ but slightly in construction, the principal variance being in the surface of the roller.

b. A hand-tool for shaping the curve of the heel.

Fig. 2493.



Heel-Trimmer.

A curved knife set in a shank whose lower end by contact with the lower surface of the heel forms a guide.

Heer. (*Weaving.*) The length of two cuts or *leas* of linen or woolen threads.

Hel'i-cal Spring. A spring whose coils have a gradually decreasing diameter, as the mainspring of a watch. It may lie in one plane like a fake of rope, one layer of rope as coiled up; or it may be like the architectural helix or the helix of a shell, and assume a conical form.

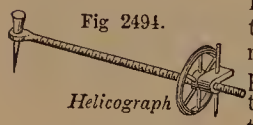
A spiral spring is a coil whose rounds have the same diameter.

A helical spring whose coils are in the same plane is used by alternately expanding and contracting in that plane, as with the pendulum spring and mainspring of an ordinary watch.

When the spring is more or less conical, it may be used either in the way just stated or by compression in the line of its axis.

Hel'i-co-graph. An instrument for describing helices. The small wheel rotates on the screw-shaft and revolves around the fixed point, moving towards or from the said center, according to the direction of its revolution; the pencil describing a helix, the distances between the intersections of an ordinate with the spiral are equal to the *pitch* of the screw.

Fig 2494.



Helicograph

Hel'i-con. (*Music.*) A form of wind-instrument of metal, resembling a French-horn, but having keys and valves. They are made *en suite*, that is, of various sizes and compass. See Horn, *e*.

He'li-o-chrome. (*Photography.*) The name given by Niépce de St. Victor to the products of his process for photographing in the natural colors. A consummation devoutly to be wished, often announced with a flourish of trumpets and a new name, but not yet seen. Some indications yet afford a hope.

He'li-o-chro'mo-type. (*Photography.*) A sun-picture in the natural colors: long desired, partially obtained, but always fugitive — so far.

He'li-o-graph. (*Photography.*) 1. A sun-picture. *Heliography* is the name given to the art of taking *sun-pictures* by Nicéphore Niépce, who was the first to take a permanent picture. He used the bitumen of Judea on tin and pewter plates. He commenced in 1814, thus preceding Daguerre, who worked upon silver plates with the vapors of iodine and mercury. In 1829 they became associated, and thereafter they worked together. See Photography.

2. An instrument constructed by De la Rue for obtaining photographs of the sun. It is mounted equatorially. The image of the sun, 0.466 inches in diameter at the focus, is enlarged to nearly 4 inches by means of a secondary object-glass, and this image is received on a photographic plate. The sun's light is so intense that not only has the aperture to be cut down to 2 inches, but an instantaneous apparatus of peculiar construction has to be employed. When the picture is about to be taken, an opening, $\frac{1}{10}$ of an inch wide, flashes across the axis of the secondary object-glass, and the rays from the different parts of the disk pass through it in succession and are depicted on the collodion plate. — Brande.

He'li-o-graph'ic En-grav'ing. (*Photography.*) The process of Niépce de St. Victor was to coat a plate with bitumen; expose it with an engraving over it, the bitumen being, by the joint action of light and oxygen, rendered insoluble by the usual solvent. The solvent then removes the parts protected by the lines of the engraving, and the bare metal is etched by an acid.

Fox Talbot coated the plate with gelatine and bichromate of potash, and exposed it under a positive. The gelatine became insoluble where the light acted; where the film had been protected by the lines of the engraving it was washed away by water, and the lines were *bit in* by bichloride of platinum, or perchloride of iron, the other parts of the plate being protected by the film.

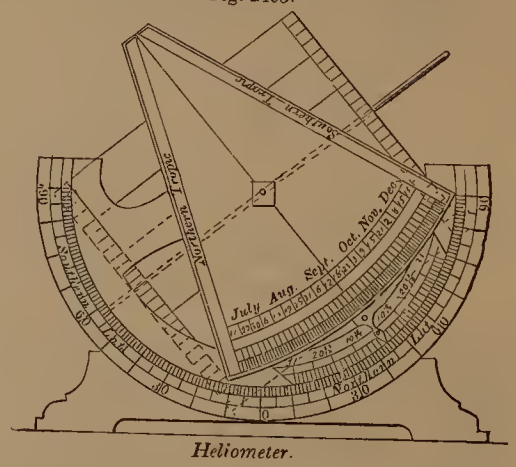
Salmon and Garnier produced another process, in which a brass plate was subjected to the action of iodine vapor and then exposed under a negative. Being then rubbed with wadding charged with globules of mercury, the latter is found to adhere only to the parts corresponding to the blacks of the negative. An ink-roller being passed over it, the amalgamated parts refuse the ink and form lights on a black ground. The variations in the process, and also those incident to the different proceedings thereafter, to fit it to be used as a copper-plate by etching, or in the manner of a lithographic stone, cannot be here detailed. See Sutton's Dict., "Photography."

He'li-om'e-ter. 1. (*Optics.*) A double object-glass micrometer (see Micrometer), called a heliometer from its being originally used for measuring the angle subtended by the sun. The telescope, in whose field it is placed, is usually of large size and mounted equatorially; that is, having two axes of motion at right angles to each other; one parallel to the axis of the earth and the other to the equator.

The instrument was suggested by Roemer about 1678, and brought into use by Bouguer about 1748. G. Chambers credits its application or improvement to De Charmères, a French naval officer of the last century.

The object-glass is divided diametrically, and the parts are capable of motion in their own planes, and

Fig. 2495.



Heliometer.

through considerable intervals by means of screws, and thus their optical centers can be separated. Each half-glass forming a separate image of any object, the two images will be at an angular distance, dependent on the amount of separation of the centers of the two half-glasses. Dolland called it "a *divided object-glass* micrometer."

2. A form of dial. An instrument for ascertain-

ing the solar time in all latitudes, and for ascertaining the latitude when the apparatus is set at noon according to the date. Also for ascertaining the date and length of day, sunrise and sunset, other conditions being established. Also, the differences of time between two places, the position of the earth's axis in relation to the level at the point of observation, etc. It does not admit of a brief description.

He'li-o-scope. (*Optics.*) The name given by Scheiner (1625) to an instrument of his own invention for observing the sun without hurting the eye.

Such instruments have a semi-opaque medium; shut off the greater portion of the rays; or have reflectors which transmit but a small portion of the rays.

Huyghens, in making a comparison of the intensities of the solar light and that of Sirius, employed upon the former a tube having a very small aperture at one end, into which was inserted a minute globular lens, which allowed only $\frac{1}{27664}$ part of the solar disk to be seen. He found this portion afforded a light equal to that of Sirius, and concluded that Sirius was 27,664 times more distant than the sun.

He'li-o-stat. (*Optics.*) An instrument invented by Gravesand, 1719, by which a sunbeam may be steadily directed to one spot during the whole of its diurnal period. Improved by Malus, Foucault, and Dubosq.

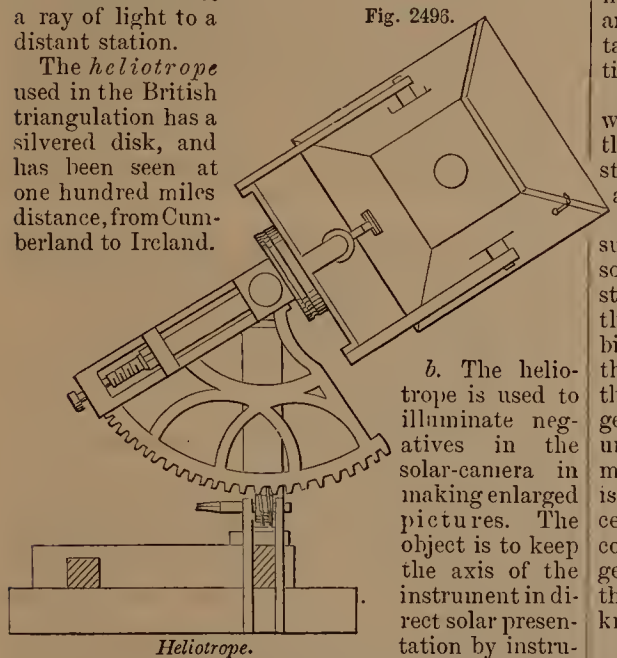
The object of the instrument is to make a sunbeam apparently stationary for purposes of experiment, obviating the inconvenience arising from the continual change of direction of the solar rays.

It consists of a plane metallic mirror, having a vertical and horizontal movement, and of a clock, the index of which moves in a plane parallel to that of the equinoctial. The extremity of the index is connected by a rod attached behind the mirror in the line of its axis. See HELIOTROPE; SOLAR-CAMERA.

He'li-o-trope. (*Optics.*) *a.* A geodetical instrument used to reflect a ray of light to a distant station.

The *heliotrope* used in the British triangulation has a silvered disk, and has been seen at one hundred miles distance, from Cumberland to Ireland.

Fig. 2496.



Heliotrope.

b. The heliotrope is used to illuminate negatives in the solar-camera in making enlarged pictures. The object is to keep the axis of the instrument in direct solar presentation by instrumental means. In the example, the optical axis of the instrument is brought parallel with the sun's rays, and kept coincident therewith by the adjustments described, a motor and a pendulum, or other time-keeper.

c. The ancient Greek *polos* or *heliotrophion* was a basin in the middle of which was a perpendicular staff or finger, whose shadow indicated on lines the twelve parts of the day; so it was a kind of dial.

He'li-o-type. (*Photography.*) Speaking generally: any process for obtaining pictures by the actinic power of the sun's rays on a prepared surface, from which to print in fatty inks. Specifically, the Edwards process developed step by step in the following way.

The action of hot water on gelatine is to dissolve it; the action of cold water is not to dissolve it, but to fill up the pores and swell it up, just as in the case of a sponge. As, after exposure to light in presence of a bichromate, hot water will no longer dissolve gelatine; so, after exposure, cold water will no longer expand it, — can no longer penetrate the pores. The light has had the effect of closing the pores, and thus rendering the gelatine water-proof. If a plate be covered with bichromated gelatine, and exposed to light under a negative, certain pores will be *completely* closed; the medium-tones will have the pores partly closed; and in the unlighted parts the condition of the gelatine will be unchanged. If this plate be steeped in cold water, some portions of it — those where light has not acted — will absorb water, and others will refuse to do so, having been water-proofed by light. On rubbing grease over the plate, the result will be that where the pores are full of water — that is, where the light has not acted — the grease will not touch the gelatine; but where the light has acted, the pores are closed, there is no water, and grease attaches itself readily; where the light has partly closed the pores, the small quantity of water absorbed does not prevent a small quantity of grease attaching itself. Lithographic ink is simply grease to which coloring matter has been added; and a lithographic roller charged with such ink, and rolled over such a plate, speedily reveals the light-produced image.

This method was discovered by Poitevin, and patented by him, as early as 1855. The process was not immediately successful, owing to the spongy and delicate nature of gelatine, the difficulty of obtaining intensity in the inking of the depressed portions, and the lack of sharpness.

Du Motay and Marechal used a very thin film in working by the Poitevin method, but failed to make the gelatine withstand the pressure. They also substituted alkaline trichromates for acid bichromates, and proposed the addition of reducing agents.

Herr Albert of Munich next produced some results by a similar method. His plan of working is somewhat as follows: instead of a lithographic stone, a glass plate is employed, of considerable thickness. On this is placed a layer of gelatine and bichromate, which, when dry, is hardened through the glass from the back, by exposure to light. On the top of this is placed a second thin coating of gelatine and bichromate; and this is exposed to light under a negative, and then hardened by chemical means. In this manner a compound printing film is obtained, having the necessary thickness to stand a certain amount of wear and tear, whilst, from its construction, the difficulty of the swelling of the gelatine is to a great extent got over; the plate is then inked and printed in the usual way. This is known as ALBERTYPE (which see.)

Edwards added to the known data, producing a film which is movable. By the addition of alum, more especially chrome alum, to the gelatine, a film can be produced consisting of a tough, tawny, insoluble substance, like leather or parchment, capable of standing an apparently unlimited amount of rough usage. Edwards discovered that gelatine might be converted into this substance, but that it still retained its property of being acted on by light in presence of a bichromate, and of receiving and

refusing greasy ink. The practice is to produce by light on a sheet of bichromatized gelatine, by means of a photographic negative, the same result that is produced in lithography by drawing on a stone with a greasy ink; that is to say, where the light has acted, just as where greasy ink has been used, water is repelled; where light has not acted water is absorbed and grease repelled, and where light has partly acted, as in the half-tones of a negative, water is partly absorbed and grease partly repelled. Ordinary gelatine is dissolved in warm water, and a sufficient quantity of *bichromate of potash* is added to render it sensitive to light, and of alum to make it very hard and durable. This is poured on a level plate, previously rubbed over with wax, and is dried in the dark by means of heat. As soon as dry, or when required for use, the sheet of gelatine is stripped from the plate, and printed under a photographic negative; the side of the gelatine which has been next the glass, and which is consequently free from dust, etc., being that on which the image is obtained. When the picture appears sufficiently plain, the sheet of gelatine is taken from under the negative, and made to adhere to a metallic plate. The method of adhesion used is that of atmospheric pressure. The sheet of gelatine and the metallic plate are put together under water; as much of the water as possible is got rid of from between the two surfaces, the gelatine absorbs the remainder so that a vacuum is created, and the picture is thus attached to the plate by the weight of the atmosphere. The superfluous chemicals are soaked out with water, and the plate, with the printing-surface of gelatine attached, is placed on an ordinary platen printing-press, and inked up with ordinary lithographic ink. As in lithography, it is necessary after every impression to damp the plate with water. A mask of paper is used to secure white margins for the prints, and the impression is then pulled and is ready for issue. Two or more inks are sometimes used in the production of one picture, as it is found that where the light has acted deeply a stiff ink is required, but where it has acted not so deeply — that is, in the half-tones — a thinner ink may be used. So that a stiff ink is first used for the shadows, and a thinner ink afterwards for the half-tones. In this manner several inks may be used in printing one impression. The effect of India or other colored tint is obtained by using, instead of ordinary water for dampening the plate, water with some color in it. The paper absorbs a certain amount of water out of the plate, and with it the desirable amount of color. The ordinary rollers are not found to be satisfactory, and a mixture of gelatine, glycerine, and castor-oil is used.

Edwards's process is worked in the United States by James R. Osgood & Co., publishers, of Boston, who own the patents.

He'lix. 1. A curve generated by winding a line around in a coil of gradually increasing radius, and maintaining the same plane; or by winding the line on a cone on which it ascends in winding.

The flat watch-spring, or the *fakes* of rope in a *tier*, are instances of the *flat helix*.

The *conical helix* is shown at *w x* (Fig. 1143), and is common as a spring in bed-bottoms and upholstery.

2. (*Architecture.*) The volute under the abacus of the Corinthian capital.

The words *helix*, *coil*, and *spiral* should not be used as if they were mere synonyms. Preferably, *coil* is the generic word, and signifies a winding; a *helix* is a flat or conical coil, as just described; a *spiral* is a coil which advances in the direction of the length of its axis, like a wire which is wound around a cylinder maintaining contact therewith throughout the length of the wire so wound, and progressing in the length of its axis; the spiral is seen in the chronometer-balance (Fig. 532) and in the car-springs *m* to *v* (Fig. 1143).

Hel-len'o-type. (*Photography.*) A picture in which two finished photographs are used. One is taken very light, the paper made translucent by varnish, tinted on the back, and laid the stronger print, so that there is a combination of effects.

Helm. (*Nautical.*) The rudder and its operative parts; such as *tiller* or *wheel.*

"The ships . . . . are . . . . turned about with a very small *helm*, whithersoever the governor listeth." — JAMES iii. 4.

When the helm is *a-starboard* the tiller is over to the right side, the helmsman looking forward.

A-port; it is to the left side.

Up; it is to the weather side.

Down; it is to the lee side.

Helm-port. The opening in the counter through which the head of the rudder passes.

Hel'met; Helm. *a.* Defensive armor for the head. *Casque*, *head-piece*, *morion*, are other names for the same thing. It was anciently formed of skins, leather, brass, iron, and still survives in the metallic and leather helmets of European armies.

Dr. Abbott's collection in New York has the helmet of Sheshonk or Shishak, with his cartouche upon it.

Herodotus states that "the Carians were the inventors of three things, the use of which was borrowed from them by the Greeks; they were the first to fasten crests on helmets, to put devices on shields, and handles on shields."

Herodotus describes (Book VII.) the following head-dresses of the nations forming the motley army of Xerxes: —

"The Assyrians had helmets of bronze or iron." Layard found some of the latter metal at Nineveh.

The Scythians had "tall, stiff caps, rising to a point." They were probably of felt.

The Ethiopians "wore upon their heads the scalps of horses, with the ears and mane attached; the ears were made to stand upright, and the mane served as a crest."

The Paphlagonians had leather helmets.

"The Thracians wore skins of foxes upon their heads."

"The Chalybes had brazen helmets, and above these they wore the ears and horns of an ox fashioned in brass. They had crests on their helms."

"The Milyæans had skull-caps of leather."

The Moschians and Colchians, wooden helmets.

The Mares had plaited leather helmets.

The Persians, soft caps.

The Lycians, hats with plumes.

Some of the Assyrian contingent wore fillets round the head, — perhaps turbans.

b. A diver's helmet is made of thin sheet-copper, furnished with eye-holes, the glass of which is protected by brass wire. It comes well down over the breast and back, and is fastened by rivets to a water-proof canvas jacket, so tightly that no water can penetrate.

To the helmet are attached the elastic tubes by which vital air is supplied to the diver and the exhausted air removed. The supply-pipe communicates above with the barrel of an air-pump, and the fresh air from above is made to impinge upon the inside surface of the glasses so as to evaporate the moisture condensed from the breath of the diver. See ARMOR, SUBMARINE DIVER'S, page 714.

Helve. 1. The handle or shaft of a chopping-tool, such as an axe, adze, or hatchet. See HANDLE.

2. A tilt-hammer, used for shingling the balls as they come from the puddling-furnace.

Helve-ham'mer. A ponderous blacksmith's hammer, tripped by the helve and oscillating on bearings. A *trip-hammer*.

Hem'a-drom'e-ter. (*Surgical.*) An instrument for measuring the velocity of the blood in the arteries.

Hem'a-dyn'a-mom'e-ter. (*Surgical.*) An instrument for measuring the force of the current of blood in the arteries, by ascertaining the hight to which it will raise a column of mercury.

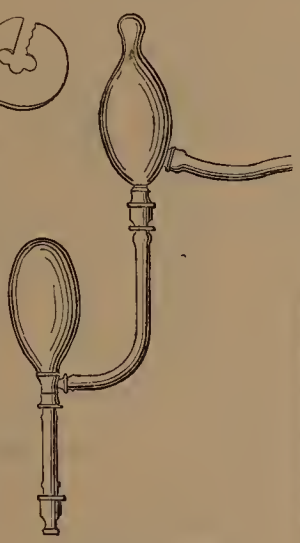
Hem'i-spheres of Mag'de-burg. Devised by Otto Güericke, 1654, to illustrate the pressure of the atmosphere. See MAGDEBURG-HEMISPHERES.

Hem'mer. An attachment to a sewing-machine for turning over the edge of a piece of fabric or a garment, in order that the flap may be stitched down. As the fabric is fed along, the edge is turned over in a curved path, and is then flattened by the presser-foot ready for stitching by the needle.

Fig. 2497.

Hemmer.

Fig. 2498.



Hemorrhoidal-Syringe.

Hem'or-rhoid'al-syr'inge. (*Surgical.*) A form of injection-syringe for the treatment of piles. In the example, the nipple on the bulb enters the rectum, and a stream of cold water is passed through the bulb, and circulates within the closed portion within the rectum.

Hemp. Hemp is not mentioned in our translation of the Hebrew Scriptures, and but sparingly in the Greek classics.

Hesiod and Homer make no mention of hemp. It is first mentioned by Herodotus : —

"Hemp grows in Scythia ; it is very like flax ; only it is a much coarser and taller plant ; some grows wild about the country, some is produced by cultivation. The Thracians make garments of it, which closely resemble linen." — HERODOTUS, IV. 74. He elsewhere states that they buy it of the Northern people.

Hesychius says the Thracian women made sheets of hemp. The people of that country yet wear tunics of hemp, and some are employed in towing the boats on the Danube between Pesth and Vienna.

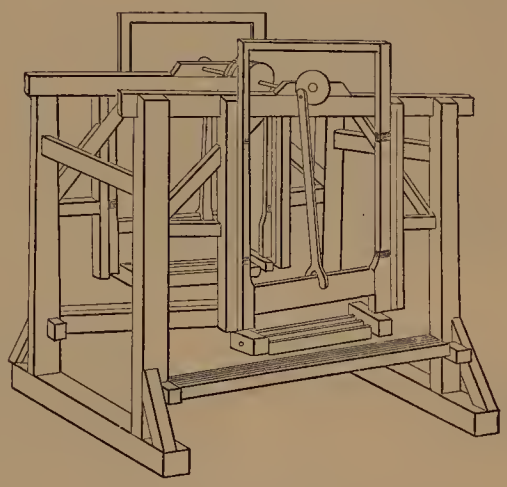
Hempen ropes were used on board the "Syracusia," built for Hiero, as recorded by Moschion. There are many other notices of hemp by later authors. It was imported in the bank or bale from the country of the *Rhodaunus*, which empties into the Vistula. The Greeks and Romans used tow for calking the seams of their vessels, but did not cultivate it before the Christian era.

Hemp was known to the Roman naturalists, but does not seem to have been used as a fiber plant. It was known to the Anglo-Saxons, and the mode of preparing and beating it is given by Strutt. Hempen cloth became common in Middle and Southern Europe in the thirteenth century.

For specific list of appliances in the treatment and manufacture of hemp and other fiber, see COTTON, FLAX, WOOL, HEMP, etc., APPLIANCES.

Hemp-brake. A machine in which rotted and subsequently dried hemp-stalks are beaten to remove the bark and cellular pith from the fiber. Among the forms of the machine may be noticed the simple sword or slats driven between two slats set edge up ; the hemp is laid crossways of the slats, and is violently bent by the blow, cracking off the scale of bark and powdering the pith.

Fig. 2499.

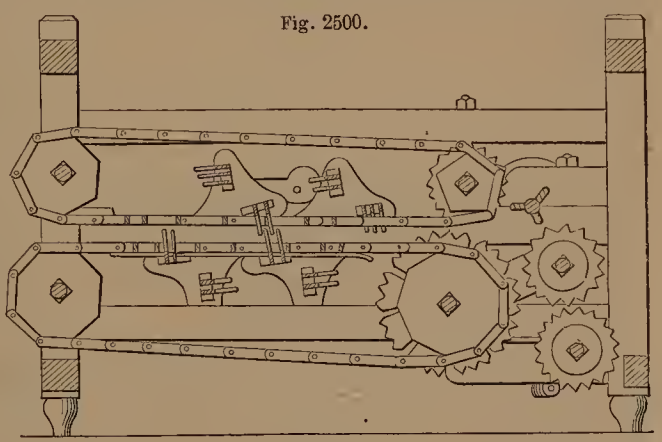


Hemp-Brake.

In Fig. 2499 the slats of the reciprocating portion and of the bed are arranged in gangs, to break the stalks which are laid crossways between them. The brake is in a gate which moves in guides by means of a pitman from a wheel above.

Other forms of brakes have rotatory motion. A series of fluted rollers whose projections interlock like cogs. Slatted interlocking cylinders. Planetary systems of fluted rollers, operating on beds of fluted rollers. In the example, the hemp is passed between braking rollers and thence is carried forward by and between endless slatted carriers, where it is broken by the action of oscillating beaters above and below, whose teeth strike it in concert between the bars of the carriers.

Fig. 2500.

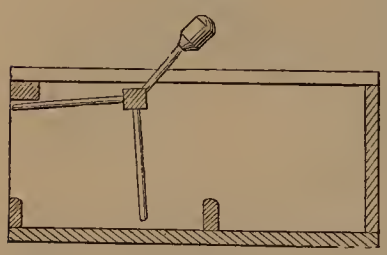


Hemp-Brake.

Hemp-har'vest-er. (*Agriculture.*) A reaping-machine for hemp. Hemp-harvesters resemble those for corn in their adaptation to operate upon tall top-heavy stalks, but as the stalk of the hemp is the valuable portion, the machine is made to cut low. One form of the machine is a puller which grasps the stalks near the ground and uproots them. Among the varieties of machines may be cited a low platform on wheels, with a cutter-bar in front, a reel to gather them to the knife and direct them over into a cradle where they are collected in a bunch. In another form, the stalks are caught by an arm till a shock is collected. In another, the stalks fall on an obliquely traversing apron which conducts them laterally and discharges them upon the ground out of the way of the horses the next time round. A stalk-puller consists of a pair of revolving disks on axes set at an obtuse angle with each other, so as to grip the stalks which are conducted between them at the lowest part of their revolution, and then open as they rotate and allow the stalks to fall into a cradle or on to the ground.

Hen's-nest. A box which furnishes a place for a fowl to lay her eggs. Contrivances have been suggested more curious than useful, and some so complicated that only well-trained hens could be expected to occupy them, and not then if in a hurry. The example has a pivoted or suspended door, counterpoised and arranged in such a manner that but one hen can enter and sit upon the nest at once. The object is to prevent hens laying eggs in the nests of setting hens, and also to prevent one hen from driving another off the nest.

Fig. 2501.



Hen's-Nest.

Her-ba'ri-um. A collection of dried plants.

Aristotle is considered the founder of the philosophy of botany, 347 B. C. The "Historia Plantarum" of Theophrastus was written about 320 B. C. Authors on botany were numerous at the close of the fifteenth century. The Botanic Gardens of Padua, Leyden, and Leipsic were established respectively in 1545, 1577, 1580; the Jardin des Plantes, in Paris, in 1624; Oxford, 1632. The system of Linnæus was made known in 1750; and Jussieu's system, founded on Tournefort's, and called the "natural system," in 1758. The latter is now accepted by such authorities as Lindley and Loudon. The Linnæan was founded upon sexual differences, the classes being determined by the number of stamens, the orders by the number of pistils. The natural system of Jussieu is founded upon modes of growth and fructification. At the death of Linnæus, the number of species described was 11,800. The number of species now recorded is probably nearly 100,000. See Loudon's "Encyclopædia of Plants," 1829.

Amateur collectors may be interested in hearing the statement of a German naturalist, that the catalogue of useful plants has risen to about 12,000, but that others will no doubt be discovered, as the researches yet made have been completed only in portions of the earth. Of these plants there are 1,350 varieties of edible fruits, berries, and seeds; 108 cereals; 37 onions; 460 vegetables and salads; 40 species of palms; 32 varieties of arrowroot; and 31 different kinds of sugars. Various drinks are obtained from 200 plants, and aromatics from 266. There are 50 substitutes for coffee, and 129 for tea. Tannin is present in 140 plants, caoutchouc in 96, gutta-percha in 7, rosin and balsamic gums in 387, wax in 10, and grease and essential oils in 330; 650 contain dyes, 48 soap, 260 weaving-fibers; 365 fibers used in paper-making; 48 give roofing-materials, and 100 are employed for hurdles and copses. In building 740 plants are used, and there are 615 poisonous plants. Some of these groups are evidently underestimated.

Her'is-son. (*Fortification.*) *a.* A beam armed with iron spikes and used as a barrier to block up a passage.

b. A barrier of the nature of a turnstile.

Her-maph'ro-dite. (*Nautical.*) A form of vessel having the forward mast and bowsprit of a brig and the after mast of a schooner, each with its proper proportions, station, rig, and sails.

Her'ni-al Sup-port'er. See Truss.

Her'ring-bone. 1. (*Masonry.*) Rows of stone or paving-blocks sloping in different directions in alternate rows. See Masonry.

2. (*Building.*) Strutting-pieces between thin joists, diagonally from the top of one to the bottom of another, to prevent lateral deflection.

3. (*Sewing.*) A cross-stitch in which the threads are laid diagonally in rows.

Her-schel'i-an Tel'e-scope. A form of reflecting telescope having no second mirror, but a speculum placed in an inclined position so as to bring the focal image near the edge of the tube, where it is viewed directly by the eye-piece, without materially interfering with the light entering the telescope from the object observed.

The magnifying power is equal to the focal length of the object-mirror divided by that of the eye-glass. See Telescope.

Herse. 1. (*Fortification.*) (From French *herse*, a harrow.) *a.* A gate with cross-bars and spiked, and serving to obstruct a passage-way, on occasion. A *portcullis.*

b. A frame with spikes, acting as a *cheval-de-frise*, to impede an advance. A *hersillon.*

c. An openwork gate which obstructs passage along a ditch or watercourse, or a sally-port traversable by boats.

2. A rectangular frame made of four bars, and having pegs on which are wound the straining strings attached to the edges of a skin which is stretched in the frame, to remove its wrinkles and hold it while being scraped. Skins for parchment are thus stretched for fleshing, scraping, and grinding. See Parchment.

Her'sil-lon. (*Fortification.*) A beam, frame, or plank set with spikes to stop a breach or way. A *herse*; a *cheval-de-frise.*

Hesp. (*Weaving.*) The length of two hanks of linen threads.

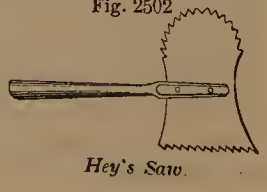
Het'e-rod'ro-mous Lev'ers. The windlass, capstan, winch, crank, crane, etc.

Hewn-stone. Stone blocks in which the faces are hammer-dressed to shape.

Hex'a-chord. A musical instrument with six strings.

Hey's Saw. A saw invented by the celebrated surgeon whose name it bears. It has one curved and one straight serrated edge. Used in making exsections, operating on the cranium, and removing carious bones from deep-seated places.

Fig. 2502



Hey's Saw.

Hide. A flayed skin of an animal. For specific index see Leather.

The ancient Scythians made quiver-covers of the skins of the right arms of their enemies. The nails were left hanging to them. "Now the skin of a man is thick and glossy, and in whiteness surpasses almost all other hides. Some even flay the entire body of the enemy, and, stretching it upon a frame, carry it about with them wherever they ride." — HERODOTUS, IV. 64.

Cambyses killed and flayed a venal judge, afterwards cutting his skin into strips for a chair-seat, as a reminder for the son, the subsequent occupant of the chair and office. See CHAIR.

The skin of the Silenus Marsyas, flayed by Apollo, as the Phrygian story goes, was hanging in the market-place of Celænæ in the time of Herodotus. It was still shown there in Xenophon's time.

The sides of hides are the *flesh* side; and the *grain* or *hair* side.

Depilation is known as *unhairing*.

Puling is unhairing by hanging in a damp heat.

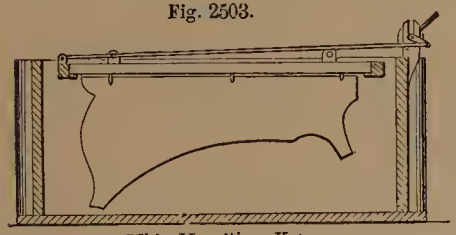
Fleshing is paring to a smooth surface by removal of fat and integuments.

Swelling is puffing it out by stuffing, etc.

Dressing embraces a number of operations in preparing the tanned hide for the use of the shoemaker, saddler, etc. See list under LEATHER.

Hide-hand'ler. A machine or vat in which

Fig. 2503.



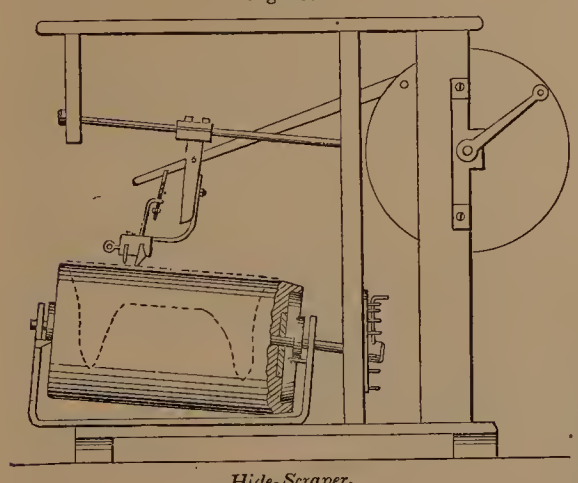
Hide-Handling Vat.

hides are moved in the liquor to expose them to the liquid in circulation, and sometimes alternately to the air and the liquor.

Hide-rope. Rope made of strands of cow-hide plaited. It is used for wheel-ropes, traces, purchase-ropes, etc. See RAWHIDE.

Hide-scrap'er. (*Leather.*) One to perform by machinery the business of scraping the flesh-side of

Fig. 2504.

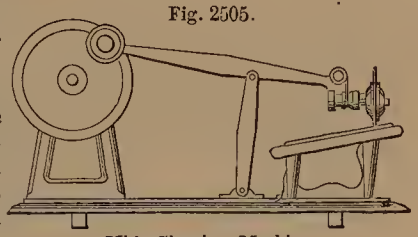


Hide-Scraper.

hides. In the example, below the reciprocating scraping-knife is a drum, upon which the hide to be scraped is secured. The drum may be vertically adjusted to the knife by means of eccentrics, and is partially rotated after each movement of the knife to bring a fresh portion of the hide into the proper position to be scraped.

Hide-shav'ing Ma-chine'. (*Leather.*) A machine having a cutting, shaving, or scraping-tool which reciprocates above an inclined table on which the hide is stretched. In the example, the tool has also a rotary motion imparted to it by means of a band.

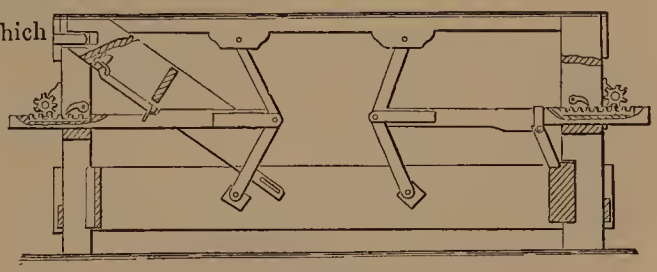
Fig. 2505.



Hide-Shaving Machine.

Hide-stretch'er. (*Leather.*) A frame on which a hide is stretched to bring it to shape and remove wrinkles. In Fig. 2506, the hide is laid over a beam, and the edges of its depending sides are depressed by clamps and toggles, which are operated

Fig. 2506.

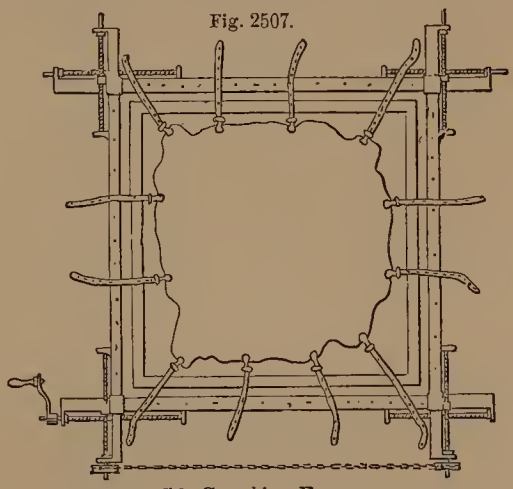


Hide-Stretcher.

by rack-bars and pinions, the adjustment of the latter being maintained by pawls.

In Fig. 2507, the pivoted nippers are tightened on the hide by the straps that suspend it within the

Fig. 2507.



Hide-Stretching Frame.

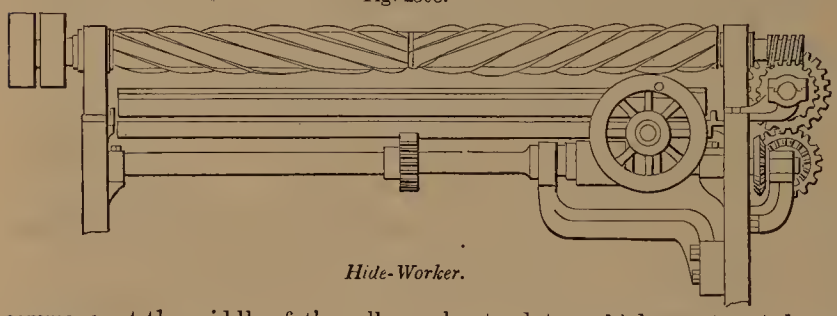
frame. The latter is expanded by screws at the corners.

Hide-work'er. A machine for performing that part of the currying operation which consists in evening the thickness by means of knives, which, in the hand-operation, are applied to the hide while lying upon a slanting post called a *beam*. See CURRYING.

In the machine (Fig. 2508) the table moves in a frame and is covered successively with cork or vul-

canized rubber, felt, and cow-hide; it passes under a roller armed with two sets of spiral blades which

Fig. 2508.



Hide-Worker.

commence at the middle of the roller and extend to its ends.

High-fur'nace. (*Metallurgy.*) A smelting-furnace of full hight, in contradistinction to a certain smaller furnace known as the *half-high furnace.*

High-press'ure A-larm'. The object of this device, as the name indicates, is to give notice and prevent an explosion of a steam-generator. It consists mainly of two classes: 1. Fusible plugs in the side of the boiler, which give way when a certain heat is attained, and allow the steam to escape. 2. Valves which open when the pressure becomes excessive, and allow exit to steam, which blows an alarm-whistle. The first depend upon temperature, the second upon pressure. Pressure and temperature bear a certain ratio to each other.

1. Ashcroft's patents of March 19, 1850, and February 18, 1851, refer to methods for the protection and insulation of the plug which is destined to give way at a certain temperature and relieve the boiler.

The patent of C. Evans, May 8, 1834, describes the use and operation of the fusible plug, which is composed usually of lead and tin, with the addition, in some cases, of bismuth. The ingredients are so proportioned as to melt at the heat at which it is desired that notice shall be given. It is used as a low-water detector, as well as to indicate high pressure, and for protection of the boiler may be placed at that portion which is most likely to be unduly heated when the water is low. See FUSIBLE ALLOYS, p. 62.

2. The alarms acting by pressure are of the nature of the *safety-valve;* the noise of the escaping steam or its impingement upon a whistle causing an audible alarm. See LOW-WATER ALARM; SAFETY-VALVE.

High-press'ure En'gine. (*Steam.*) A steam-engine, condensing or non-condensing, in which the safety-valve is loaded with a weight equivalent to a boiler-pressure of, say, fifty pounds to the square inch. In England, above twenty-five pounds to the square inch is sometimes considered as *high* pressure. This is but an indefinite definition, but customs vary. Low-pressure engines are usually *condensing,* high-pressure engines on locomotives, saw-mills of moderate size, and Western steamboats, are *non-condensing;* but the question of condensing is not necessarily one of pressure. Things took their names early, and it is not easy to bring modern forms under an old nomenclature. All the engines of Newcomen and the early ones of Watt were single-acting and condensing, and steam much over a temperature of 212° Fah. was considered high pressure; the use of steam being merely to expel the air from below the piston, in order that the atmospheric pressure may be availed when the steam is condensed. This was all the use of steam in the Newcomen period and the early patents of Watt, which concerned the separate condenser, parallel motion, four-way cock, puppet-valves, and some other features of the engine now known as the CORNISH (which see). Watt subsequently used actual pressure of steam, was the first to use it expansively by cutting off at a part of the stroke, and also invented *double*-action engines in which the steam was admitted to alternate sides of the piston, making both motions effective. He made drawings for this in 1774, and exhibited it in 1782. He called it a "double-engine," which must not be confounded with the double-cylinder engine of Hornblower of Penryhn, patented in 1781, revived by Woolf, and much improved by Worthington. See plate opposite page 763.

Oliver Evans of Philadelphia has hardly had sufficient credit for his part in the matter, but he struggled for many years to make his townsmen believe that the high-pressure, double-acting engine was to be the engine of the future, both on roads and boats. He was active in the running of his hobby from 1787 to 1803, and in the former year obtained a patent from the State of Maryland for steam-carriages on common roads. His townsmen thought him crazy, and he could obtain no patent in Pennsylvania. He exhibited his engine running in 1803, sawing wood and stone, and grinding plaster. He put it on wheels and made it move itself to the Schuylkill, put it on board a scow, and made it drive a stern-wheel, working down the river to the junction with the Delaware, and then up the latter to the city of brotherly love but weak faith. This was some years before Fulton. He had no backers, and, having spent all his money, he, at the age of fifty, turned his excellent talents into a more lucrative channel, and was rewarded with success in business. He does not seem to have been such a fretful genius as Fitch and some others of his contemporary inventors; his portrait shows a comfortable and genial man, who retired from the unequal contest before he lost his own self-respect and became a bore. "The time" was "out of joint," and he could not convince the folks against their will. Seventy years afterward the "Pennsylvania" steamed down the river, but the intervening time might count for centuries if measured by the progress made. It may be remarked that Evans used a cylindrical flue-boiler.

Next, perhaps, we should state the work of the man who has done more than any other one man to make the locomotive what it is: Richard Trevethick of Merthyr Tydvil, in South Wales. He had not got over the idea of the necessity for something more than the weight of the engine to give tractional adherence to the rails, and used a cog-wheel and rack rail. (See LOCOMOTIVE.) He used a blast of exhaust steam in the chimney, patented his locomotive in 1802, and it was in use on the Merthyr Tydvil Railway in 1804.

Trevethick and Vivian patented the application of high-pressure steam to engines. Trevethick is described in the Catalogue of the South Kensington Museum, London, as "the inventor and constructor of the first high-pressure steam-engine, and of the first steam-carriage used in England." Blaekett improved on Trevethick, and used smooth wheels on a plate-way.

The multitubular boiler is stated to have been used by Rumsey, and subsequently, in 1790, in England. It was used by John Cox Stevens of New Jersey,

1791–1807; English patent, May 31, 1805. He used a Watt engine, cylinder 4½ inches diameter, 9 inches stroke. Boiler 2 feet long, 15 inches wide, and 12 inches high, with 81 copper tubes 1 inch in diameter. Boat, 25 feet long, 5 feet beam; tried in May, 1804; velocity, 4 to 8 miles per hour.

Not desiring to anticipate what should be said under LOCOMOTIVE and STEAMBOAT, suffice it to say that William Hadley's locomotive "Puffing Billy" was built in 1813, and had a long career of usefulness. Stephenson's first locomotive was built after seeing Trevethick's, as improved by Blackett for Lord Ravensworth's colliery, in 1814, and had grooved sheaves to increase adherence. Locomotives on Stephenson's plan were used on the Stockton and Darlington Railway, opened in 1825. Stephenson's "Rocket" was successful over three other competitors in the trial on the rails of the Liverpool and Manchester Railway, 1829. It used the multitubular boiler by the suggestion of Mr. Booth of that railway company, also the exhaust-blast in the chimney, invented by Trevethick. Hackworth's "Sanspareil" had a cylindrical flue-boiler on the Evans plan, and a very effective exhaust-blast in chimney. The "Rocket's" competitors broke down at various points in the trial. Stephenson was an excellent workman. The very insincere book called the "Life of Stephenson" ignores most of these facts, and pettifogs the whole case; it is about as one-sided an affair as Abbott's Life of Saint Napoleon, but has done much less harm, as it is only ungenerous and unfair, and does not debauch the judgment of the rising generation.

High-re-lief'. The projection of a sculptured figure, half or more, from the plane surface. Called also *alto-rilievo*. See RILIEVO.

Hight. 1. (*Hydraulic Engineering.*) The *fall* of a body of water. The *head*.

2. (*Shipwrighting.*) The distance between decks.

Hight-board. (*Carpentry.*) A carpenter's gage for *tread* and risers of a wooden stairway.

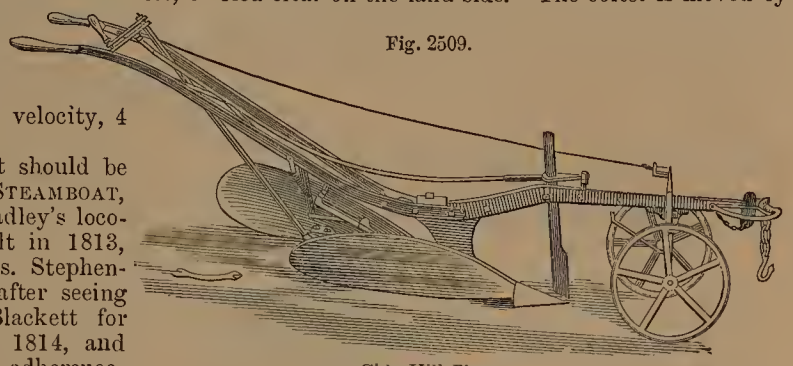
Hight-staff. (*Shipbuilding.*) A rod having marked upon it the hights above the keel of all the frames at the beam-line of the ship.

High-warp Loom. (*Weaving.*) A tapestry loom in which the warp-frame is vertical and the weaver works standing, thus being able to constantly inspect his work as it proceeds, an advantage which he does not possess in the *basse-lisse* or low-warp tapestry loom in which the warp is horizontal.

Hill'o-type. (*Photography.*) A process invented by L. L. Hill, of Westkill, New York, and much debated in the photographic journals of twenty years ago and since. He claimed — see "Photographic Art-Journal," October, 1852 — to have discovered "a method of heliotyping the colors of objects truthfully, brilliantly, and imperishably." The correspondence is voluminous, some of it acrimonious; the colors certified to have been produced heliotypically in the pictures are rosy, red, blue, green, orange, violet, buff. The process is not explained in these articles. Niépce worked long at this object, and called the products *heliochromes*. And yet we wait.

Hill'side-plow. (*Husbandry.*) One which has a turning share, so as to plow on side-hill or sidling places, returning in the last-made furrow and throwing down hill each way. The plow shown in the example is turned at the headland or end of the furrow, and by the movement of a lever the share is turned over and one *breast* is put into its proper position for work while the other is raised and carried clear on the land-side. The colter is moved by a separate lever. Such plows in England are called *turn-wrest* plows.

Fig. 2509.



Side-Hill Plow.

Hind-car'riage. (*Vehicle.*) The rear part of the running-gears of a four-wheeled vehicle. The hind wheels and axle, with or without the coupling.

Hinge. A means of connecting a door, casement, or leaf, with its frame or an object, so that it will swing thereon.

The ancient Egyptian hinges were crude affairs, and were similar in construction to those made in our early Western log-cabins. A pin projecting from the upper edge of the door was socketed in a vertical hole made in a bracket attached to the wall, and a similar pin on the lower edge of the door was stepped into a socket in the floor or threshold. The illustration *a* (Fig. 2510) is from a model house found by Mr. Salt in Egypt, and now in the British Museum. When found, it contained a supply of grain in the little store-room, but this was eaten by a rat when the model was at the Lazaretto in Leghorn, on the route for England. The grain remained in apparent good order for over 3,000 years, and was then consumed by a modern rat while the little house was in quarantine. The doors of Egypt were either single or double, and were secured by bars and bolts, as seen in the figure. The hinge-pieces were made of bronze in many cases. The accompanying figures *b c* show the upper and lower door-pins and the sockets in which the edge of the door is received, and in which it is secured by bronze pins. The projection on the upper piece was to keep the door from striking against the wall.

o shows the general form of a door in remains of stone, marble, wood, and bronze. *p* is a bronze hinge in the Egyptian collection of the British Museum. *q* is the plan of the threshold of an ancient temple with the arrangement of the folding-doors. *r s* are four Roman hinges of bronze now in the British Museum.

The term *cardo* (Lat.), a pivot or hinge, was applied to the North and South poles, on which the earth was supposed to turn. *East* and *West* being added, made the *quatuor cardines orbis terrarum*, the term yet surviving in our *cardinal points*.

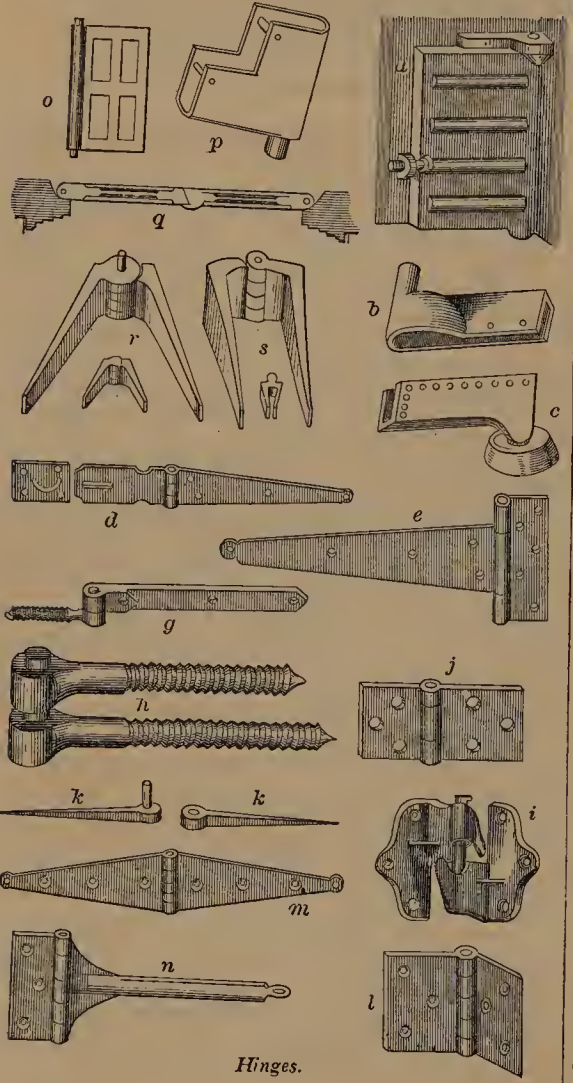
Several bronze hinges, remains of ancient Egypt, are in the British Museum. One of them is 7 inches high and 11 inches long. The basalt socket of the lower one is also in the same museum. They are from the granite sanctuary of the great temple of Karnak.

The doors of the temple of Solomon had hinges of gold. The temple seems to have been remarkable rather for lavish expenditure of gold and ornaments than for architectural beauty. Of the contemporary styles, the Egyptian and Doric, the former is the more likely to have been copied, as the Israelites

are not supposed to have originated any. They had been for several centuries in a state of transition from a nomadic to a settled life. The popular representations of the Corinthian order in the temple are anachronisms, for the temple was built 560 years before Callimachus.

There are several beautiful examples of hinge constructors in the natural world. Among them we may cite the mason-spider of the tropics and of Southern Europe. The subterranean cell of this animal is tapestried with silk and closed by an earth-

Fig. 2510.



Hinges.

kneaded door, hung upon a silken hinge and self-closing with an elastic spring, after each entrance and exit of the cavern's occupant.

Hinges are known by purpose, as, —

Blind-hinge (*i*).
Carriage-hinge.
Chest-hinge.
Door-hinge.
Gate-hinge (*g h k*).
Hasp-hinge (*d*).
Reaper-hinge.
Table-hinge (*j*).

Or by some structural peculiarity or shape, as, —

Back-flap hinge.
Butt-hinge (*l*).
Cross-garnet hinge (*n*).
Dovetail-hinge.
Hook and eye (*k k*).
Loose-joint hinge (*i*).
Screw and strap (*g*).
Screw hook and eye (*h*).
Self-shutting hinge (*i*).
Spring-hinge.
Strap-hinge (*m*).
T-hinge (*e*).

The *knuckle* receives the pin.

The leaves are *straps*.

The *rising* hinge has a spiral groove winding round the knuckle so as to lift the door when it is swung open, and thus clear the carpet.

Hinge-joint. A junction of parts allowing a flexure and extension in a certain plane. The parts are usually connected by a pintle or ligature.

Hinge-mak'ing Ma-chine'. In the Evrard and Boyer machine the sheet-metal is placed in the machine in coils, there being two coils of sheet-brass for the two halves of the hinge-body, and a coil of wire to supply the connecting bolt or rivet. The material is drawn off from the coils as it is wanted, the wings of the hinge are stamped out by punching dies to the proper shape, the salient parts, which are to form the tube for the connecting bolt, are formed upon the wire itself which is to furnish the bolt, and this is then cut off to the proper length. Before the hinge is dismissed, the screw-holes, by which it is to be secured to the wood, are formed and countersunk to the form of the screw-head. The machine completes a hinge every second.

Butt-hinges are usually molded on *match-plates*.

Hink. (*Agriculture.*) A reaping-hook.

Hip. (*Building.*) 1. The external angle formed by the meeting sides of a roof.

2. A truncated gable. See HIP-ROOF.

3. A timber which forms the angle of a hipped roof, and against which the rafters are laid.

Hip-knob. (*Building.*) The finial at the apex of a gable, or on the top of the hips of a roof.

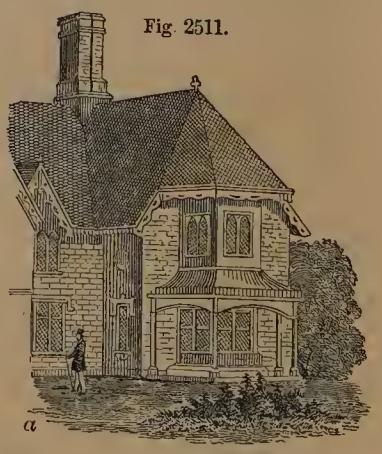
Hip-poc'ra-tes Sleeve. A strainer bag made by folding a square of flannel diagonally, and sewing it along the meeting edge, so as to make it of a funnel shape. Or, —

By uniting the opposite angles of a square piece of cloth.

Hip-raft'er. (*Carpentry.*) The rafter at the angle of a roof. Its two outer edges are sloped to range with the rafters on each side of the roof.

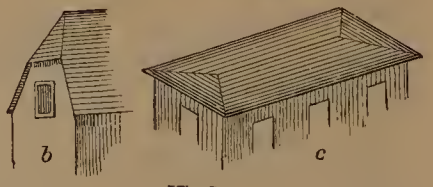
Hip-roof. (*Roof.*) An obtuse angle formed by the meeting of two portions of a roof of different slant, as in the case of a *Mansard*, *curb*, or *French* roof. See CURB-ROOF.

Fig. 2511.



A short portion of a roof over a truncated gable, as at *a*, *b*.

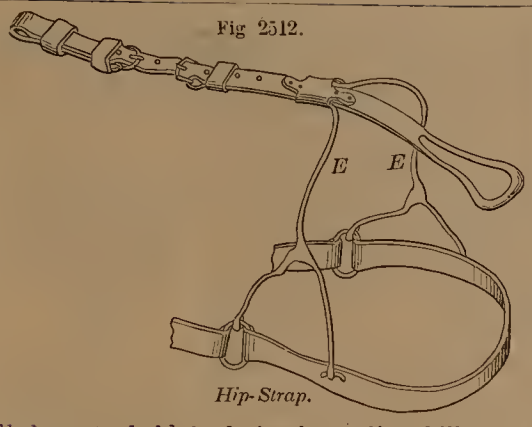
One having a double slope (*c*), the rafters at the exterior angles being in two pieces, meeting at an obtuse angle.



Hip Roof.

Hip-strap. (*Harness.*) One (*E E*) which crosses the buttocks of a horse and supports the breeching *B*, or the traces merely, according to the style of harness. It gives the name to one form of harness, called hip-strap harness, having no *breeching*. It is used for lead harness, in which the horses are not

Fig 2512.



Hip-Strap.

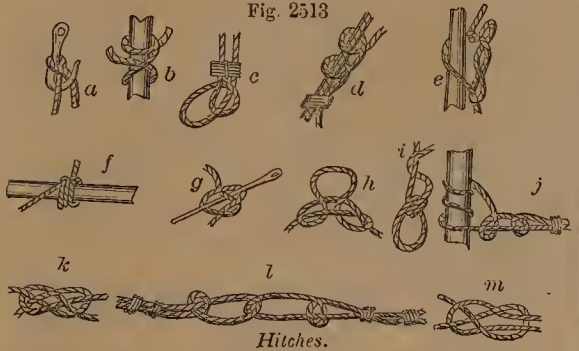
called on to hold back in descending hills, or to back the wagon.

Hip-tile. (*Roofing.*) A saddle-shaped tile to cover a hip. A *corner tile.*

Hirst-frame. (*Forging.*) The frame of a tilt-hammer.

Hitch. 1. (*Nautical.*) A species of knot by

Fig. 2513



Hitches.

which a rope is bent to a spar or to another rope. There are various kinds knows as : —

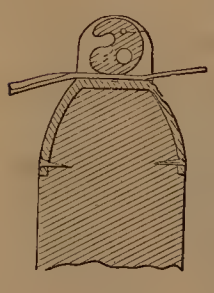
a, Blackwall-hitch.
b, clove-hitch.
c, half-hitch.
d, two half-hitches.
e, timber-hitch.
f, magnus-hitch.
g, marlinspike-hitch.
h, harness-hitch.
i, midshipman's-hitch.
j, rolling-hitch.
k, carrick-bend.
l, hawser-bend.
m, sheet-bend.

2. (*Mining.*) A small slip where the dislocation does not exceed the thickness of the vein.

Hitch'er. (*Nautical.*) A boat-hook.

Hitch'ing-clamp. (*Menage.*) A device for holding the strap of a bridle or halter. In the example, the strap is held beneath a turning cam, so as to bind the tighter the harder the horse pulls upon it.

Fig. 2514.



Hitching-Clamp.

Fig. 2515.

Hitching-Post.

Hitch'ing-post. (*Menage.*) A post with convenient means for the attachment of the strap of a horse's halter or bridle. In the example, it has a weight to take up the slack, but allows a certain freedom of motion, as the weighted tie-chain travels in the hollow post. The weight forms a stop to arrest the extraction of the chain from the post.

Hive. (*Husbandry.*) A box or basket for a swarm of bees to live in. See BEEHIVE ; APIARY.

Hoard ; Hoard'ing. (*Building.*) A temporary screen of boards enclosing a building-site, where erections or repairs are proceeding.

Hob. 1. The flat, iron shelf at the side of a grate.

2. A hardened, threaded spindle, by which a comb or chasing-tool may be cut. A *hub.*

Hob'by. The old English name of the velocipede. "Every one rides his own hobby."

Ho'bit. (*Ordnance.*) An old form of mortar of six or eight inches' bore, mounted on a carriage.

Hob'nail. A short, thick nail, with a pointed tang, a large head, and with pendent claws, which pierce the boot-sole.

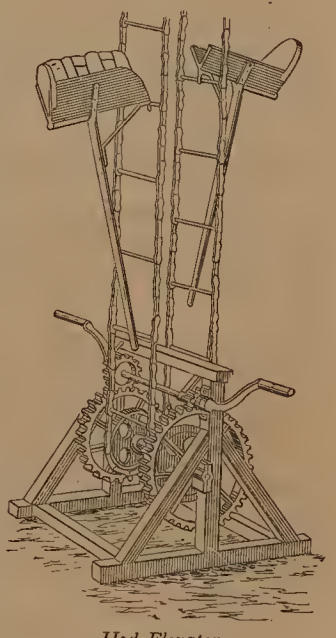
The *caliga*, or coarse shoe, of the Roman soldier, was thickly studded with hobnails.

Hod. (*Bricklaying.*) 1. A box with two sides and an end, set on edge, and with a handle by which it is carried, a padded cushion resting on the shoulder.

2. A coal scuttle or box. A coal-hod.

Hod-el'e-va'tor. A hoisting device to raise hods loaded with bricks or mortar to the building hight on a building, and return the empty ones. In the illustration, it is a traveling ladder which runs over a drum above, — not shown, — and is driven by a winch below. The hods are hooked on to the rounds.

Fig. 2516.



Hod-Elevator.

Ho-dom'e-ter. A way-measurer. See ODOMETER.

Hoe. 1. (*Agriculture.*) A tool with a flat, thin blade used to cut weeds or stir the earth around plants. In its ordinary sense, it is the familiar tool attached at a convenient angle to a straight handle, and whose duty is defined above. In England, hoes are attached to machines, but the function remains the same, for the hoes follow in the balks between the rows of plants. The same devices are here denominated *shares.*

The hoe may be fairly assumed to have been the first implement of the husbandman, in its form of a pointed stick for stirring around the roots of a plant. Next comes the crotch *a* sharpened to a point, as at *b*, in which form it might be used as a hoe or plow, according to size. *c d e* represent the hoes used by the ancient Egyptians, the two former being drawn from actual hoes which have been preserved in the tombs, and the latter (*e*) being a copy of a picture at Beni Hassan. Their hoes were made of wood, the handle was about three feet long, the blade being mortised thereto at the junction and bound by a twisted rope or thong, as clearly shown in *d*, which represents two hoes in the Berlin collection. One is also to be seen in the Abbott collection, New York. *f* shows the Egyptian plow, and is introduced to exhibit the similarity in shape of the hoes *b c* and plow

f, a crotch of a tree being the original of each. The team being hitched to the long end of the crotch *b*, the shorter end forms a share or tusk, and the back portion projects for a handle. See PLOW.

With their wooden hoes the peasants of Egypt covered the seed which was scattered broadcast over

Fig. 2517.

Hoes and Hoeing.

the surface of the land yet glistening with the mud left by the retiring Nile. Plows were also used for this purpose, and not unfrequently the seed was buried by driving herds of sheep or goats over the land.

The *bidens* or two-pronged hoe was a common tool in Roman agriculture. It was also common in Greece in the form shown at *h* (Fig. 2517). Homer describes Laertes as hoeing when found by Ulysses.

The Romans hoed their grain crops, wheat, spelt, and barley. Once in early winter, a second time in spring, before jointing. The wheat was sowed on the top of ridges made by a double mold-board plow, and was consequently in rows. It was not uncommon to hoe up the earth to the young plant at the first hoeing.

g g' (Fig. 2517) are the hoes of Pacific coast Indians. *g* is a scapula ; *g'* a walrus tooth.

Fig. 2518 shows four Japanese hoes in the collection of the Smithsonian Institution, Washington. The clumsiness of the two larger ones is something fearful to contemplate. The hoe or mattock is the usual implement for cultivating the land in Japan. The plow is also used.

Fig. 2518.

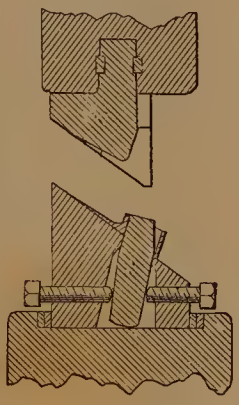
Japanese Hoes.

The hoes of Polynesia, when first discovered, were the shells of the oyster or a large kind of *pinna ;* a bone from the back of a turtle ; or a plate of tortoise-shell. The hoe was used with a thrust motion, like our Dutch hoe.

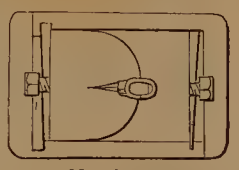
The hoe of the Fegee-Islanders is a blade of tortoise-shell or the valve of a large oyster. These may be considered a type of maritime substitutes for metal. Obsidian, flint, hard wood, and various other substitutes have been employed, the latter by the ancient Egyptians.

The Feejees are very ingenious in finding substitutes for metal. A hard stone ground to an edge forms an axe. A blade of tortoise-shell attached to a handle is their knife. The spines of echini are their boring-tools. Rats' teeth set in wood are gravers and chisels. The mushroom coral answers for a file, and pumice-stone for sand-paper. The axes and hatchets of America, and the knives and chisels of England, are fast superseding their primitive tools. They can now cut up their *bakolo* or long-pig — as they term the edible human body — with more civilized implements.

Fig. 2519.



The broad and thin metallic blade is quite a modern contrivance, and was never well made until made in the United States. It is now a scientific tool, sharp, light, and shiny. Hoes should be selected for covering or cutting ; the latter have a less angle with the handle. Clean your hoes always before putting them away, and you may always resume your work in good-humor.



Hoe-Swage.

Hoes were formerly made by forging, but now they are more often cut out as blanks and then struck in dies.

The blade being extended and the eye formed by hand, the heated blank is placed on the anvil and secured with the pin ; the drop being released falls thereon, shaping and finishing the face of the hoe.

Hoes are made in specific forms for various purposes.

a is a hoe for marking out fine drills.

b a hoe for marking small ridges.

c a hoe for working two sides of small plants.

d a hoe for drawing a pair of parallel ridges.

e a combined hoe and rake, a very common implement in the Netherlands, and used in the United States by amateur gardeners.

f has a serrated blade ; *g* a sectional one.

h i j k are *Dutch* hoes, known as *scuffle* or *thrust* hoes, operated by pushing instead of striking or pulling. They are useful in extirpating weeds under bushes, and loosening the soil around growing plants.

l shows a mode of attaching the blade to the tang.

m of wedging it in a ferrule.

n o have means of adjusting the angular presentation of the blade.

p has a reversible blade.

2. (*Dentistry.*) A dentist's excavating instrument, having a blade attached to a shank and shaped like a miniature hoe.

Hoe'ing Ma-chine'. (*Agriculture.*) An implement for tending drilled or dibbled crops. It was invented by Jethro Tull, the introducer of the system of drilled crops into England, and was designed to diminish the expense of cultivation by substituting horse labor.

Tull's implement was comparatively rude, and it was successively improved by a number of inventors, among whom we notice the names of Blackie, the

two Wilkies, Weir, Hayward, Grant, Ganett, Howard, and others in Britain.

The history merges into the history of *cultivators*, in the United States our husbandry being different.

The great breadth planted to corn and cotton, and the necessity for frequent plowings, have given a different form to the tool, as the distance between the rows renders it convenient for the horse, implement, and man to follow the balk, going twice in a row, tending the crop to his right hand each time. This is very different from the hoeing of wheat, and also from the hoeing of turnips.

The horse-hoes (*b*) of Britain have a range of shares spaced like the drills, so as to work in the intervals between the rows of plants, such as wheat and turnips. Others of their horse-hoes are for the culture of plants requiring a greater width, such as mangel-wurzel, cabbages, and beans.

The English horse-hoes *a c* have caster wheels in front and rear, a broad middle share, and two or more side shares. The rear share may be curved or flat, as shown at *c* and *a* respectively. It is what we should call a cultivator, but there is more of it than we regard convenient. If the tool be well proportioned, and the animal hitched to it rightly, it

Fig. 2520.

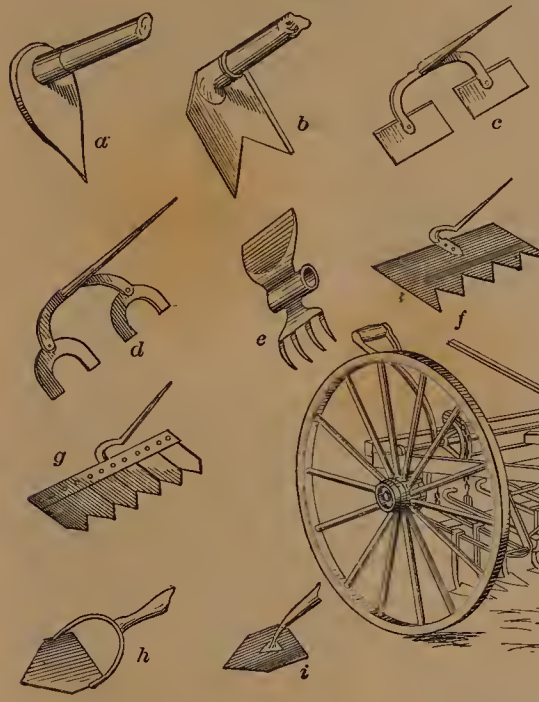
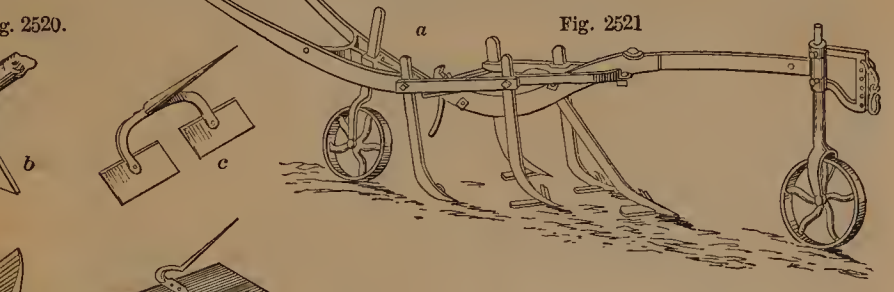
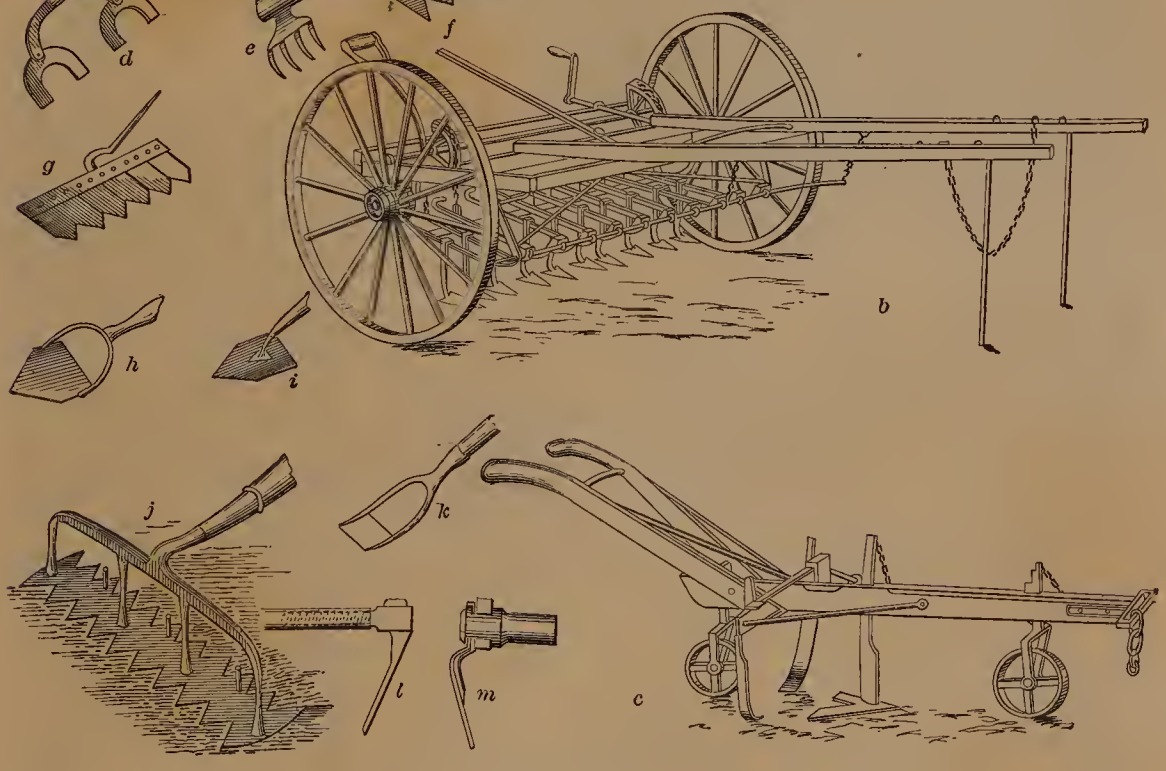
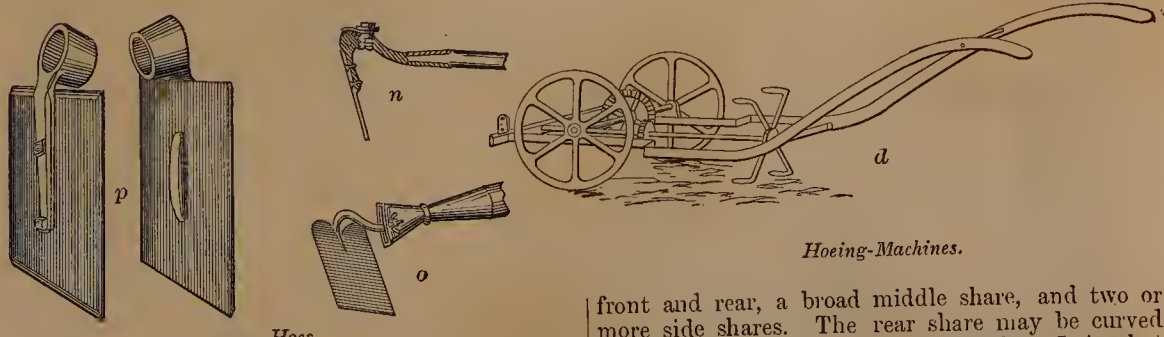


Fig. 2521





Hoes.



Hoeing-Machines.

needs no wheel. For turning at the end of a row of corn or potatoes it is too long. A man would need 12 feet of ground to come out on to turn, and it is not necessary to withdraw so large a marginal strip of the field for such a purpose. See CULTIVATOR.

Bucknalls's horse-hoe *b* (English) has a gang of 10 shares in a frame, adjustable by a lever as to hight, and also as to angular presentation of the shares to the ground. It is intended for hoeing wheat.

An implement used for chopping gaps in drilled rows of plants was described by Skirving of Fifeshire, Scotland, in 1778, and constructed by Huckvale some 25 years since (*d*, Fig. 2521). It was designed for turnip culture, and is also used in cotton culture. In each case the seed is sown somewhat abundantly in drills, and requires to be thinned after having attained such size as to bear culture. The practice with cotton has been to cut gaps in the rows with a hoe, leaving the plants in square bunches, which are afterward thinned out to a few plants, and eventually, when the contingencies of insect enemies are overpast, leaving the most likely plant in full possession of the hill.

This *horse-hoe* is designed for chopping gaps in the rows, and has a set of revolving hoes on a shaft parallel with the line of draft, and driven by bevel gearing from the main axle of the machine. As the machine advances, the hoes chop transversely across the row of plants, making intervals therein equal to the lengths of the blades. See COTTON-CHOPPER.

Hog. 1. (*Paper-making.*) A revolving stirrer in a chest of paper pulp which agitates the pulp so as to keep it of uniform consistence as it flows to the paper-making machine. See PAPER-MAKING MACHINE.

2. (*Nautical.*) A scrub-broom for scraping a ship's bottom, under water.

Hog-chain. (*Shipbuilding.*) A chain in the nature of a tension-rod passing from stem to stern of a vessel, and over posts nearer amidships; designed to prevent the vessel from drooping at the ends.

Hog-el'e-va'tor. A hoisting device used in large slaughter-houses for raising hogs which have been killed, scalded, and scraped, to the position for gutting and cleaning.

Hog-frame. (*Shipwrighting.*) A fore-and-aft frame, forming a truss in the main frame of the vessel to prevent vertical flexure.

The term "hog-frame" has been adopted into carpentry and engineering in some forms of trusses for roofs and bridges.

Hog'ger-pipe. (*Mining.*) The upper terminal pipe with delivery hose of the mining-pump.

Hog'ger-pump. (*Mining.*) The top pump in the sinking-pit of a mine. The lower is the *sump-pump*.

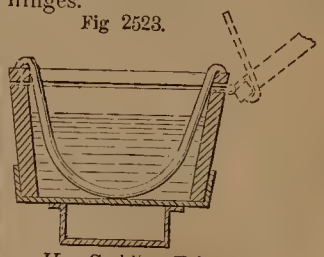
Hog'ging. (*Nautical.*) Said of a ship's shape when the head and heel of her keel are drooped; the middle portion curving upwardly. *Sagging* is the opposite curvature.

In other structures than nautical the term has the same relation, as the drooping of the ends of a truss, or the ends of a pivot bridge or table.

Hog-hook. One used in handling hogs in scalding.

Hog-scald'ing Tub. (*Domestic.*) A means for scalding hogs, consisting of a large boiler and furnace, or a tub (Fig. 2522) to hold heated stones which are thrown in to raise the temperature of the water to scalding heat. In the example (Fig. 2523) the hog lies in a cradle within the tub, whose contents are heated by the furnace below. The hog is removed and tipped out on to a bench, by vibrating the cradle on its hinges.

Fig 2523.



Hog-Scalding Tub.

Fig. 2524.

Nose-Ring.

Hog's-nose Trim'mer. A pair of cutting forceps or nippers, to remove the protuberant cartilage from a hog's snout to discourage him from rooting.

Hog-ring. A ring, or wire bent into other form, clasping the snout cartilage of a hog. In the example, the pivoted extensions of the ring penetrate the hog's snout, and, turning back, clinch round the ring.

Hoist. 1. The term applied to the elevating machinery of a factory, mine, or hotel.

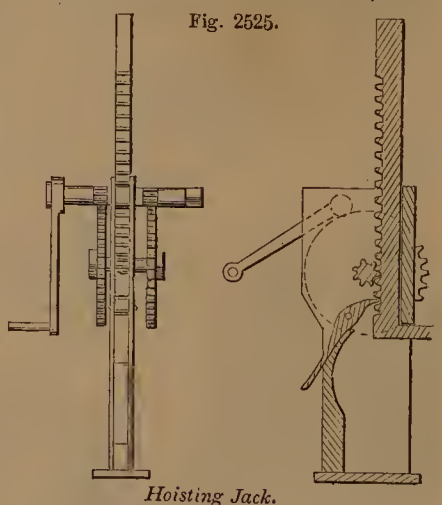
2. The perpendicular hight of a flag; the length from the spar outwards is the *fly*.

Hoist-bridge. A form of drawbridge, in which the leaf or platform is raised. See BASCULE.

Hoist'ing-en-gine. A steam-engine for hoisting at a mine, or in a warehouse, factory, etc.

Hoist'ing-jack. A contrivance by which hand-power is applied to lifting an object by working a screw or lever. A list of the different kinds is given under JACK. Several varieties are described under CARRIAGE-JACK, WAGON-JACK, JACK-SCREW, etc.

Fig. 2525.

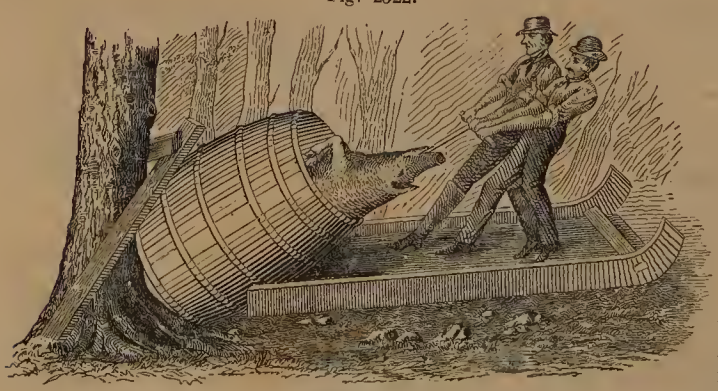


Hoisting Jack.

One form here shown operates by crank, pinions, cog-wheel, and rack.

The other is a suspensory jack, depending from an eye-bolt in a ceiling-joist and used to lift an object a short distance, so as to get it on to a store truck.

Fig. 2522.



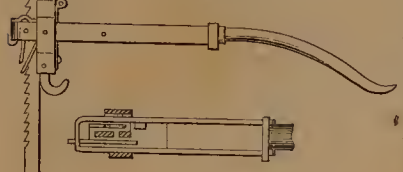
Hog-Hook.

The bars slide longitudinally upon each other, and are supported by a connecting chain which passes over a pulley. A lever on one bar acts by raising and returning stirrups upon the rack teeth of the other to raise and depress them relatively, and the rack-bar actually. The lever is locked by a stop which restrains its motions.

Hoist'ing-ma-chine'. A machine for hoisting ore, merchandise, miners, passengers, etc., in mines, warehouses, hotels, etc.

A primitive hoisting-machine, which resembles the modern capstan, is used in the Convent of St. Catharine, at the foot of Mt. Sinai, to raise travelers to a door in the second story. This is a somewhat inconvenient and tedious operation, but is used in a land where robbers go on horseback. It is also worthy of remark, that the people of the land have no idea of the value of time, and so set six men to help another in at the door. The convent was founded in the early ages of the Christian Church, and the chapel was built by Justinian in the sixth century. It is a vast, straggling building, surrounded by a high wall, and is believed by its residents to occupy the place whereon the Lord appeared to Moses in a burning bush.

Fig. 2526.



Suspensory Lever-Hoist.

Fig 2527.

Hoisting-Machine, St. Catharine's Convent, Mt. Sinai. (From Harper.)

The obelisks in ancient Egypt may have been raised by gradually lifting the apex and scotching up by introducing earth beneath them.

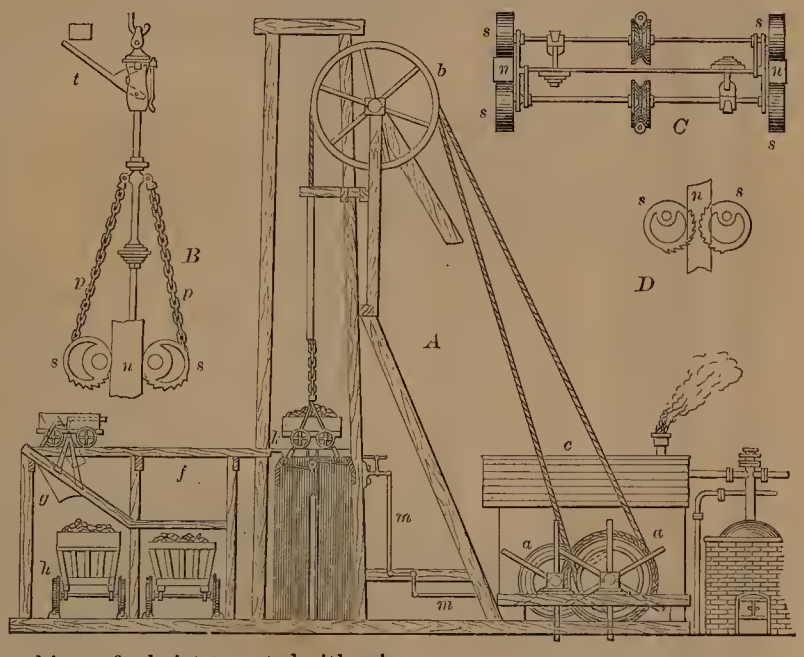
The Stonehenge blocks were probably raised in the same way.

The blocks were moved from the quarries on rollers by animal or man power. They were perhaps raised, at the pyramids, for instance, by a rocking motion on midway blocks, a rather thicker block from time to time, at each rock. Or they may have been raised on an incline of earth, afterwards removed.

When Chersiphon built the Temple of Ephesus, in the time of Amasis of Egypt, he raised the architrave by surrounding the columns with bags of earth, which served as an inclined plane.

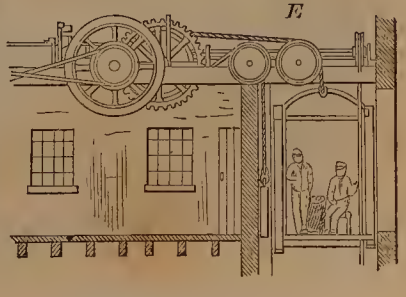
Fig. 2528 shows forms of hoisting-machines for coal-mines and factories.

Fig. 2528.



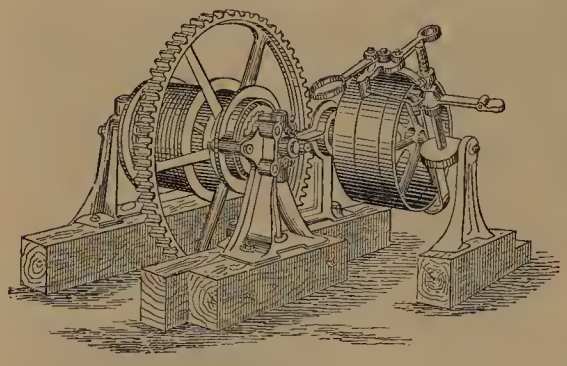
A is a general elevation of the machinery for hoisting, screening, and loading coals, which will be readily understood by merely citing the parts. *a a* are the rope-drums, driven by the engines in the house *c*; *b* the pit-head pulley; *k* the cage which lifts the folding boards of the hatchway, and then, allowing them to drop, rests upon them. The car is then run out upon the track *f*, its load dumped upon the screen *g*, and received in the wagons *h*. On the return of the empty car on to the cage, the hatches are lifted by the engine-man by means of the rods *m m*.

B, *C*, *D*, show the safety apparatus, by which, if the hoisting-rope break, the cage is prevented from falling by the biting of the toothed eccentrics *s* upon the wooden conductor *n*. The eccentrics are connected with spiral springs, which tend to rotate them, and bring the toothed part against the conductor *n*; but so long as the rope remains intact, the working faces of the eccentrics are



Mine and Factory Hoists.

Fig. 2529.



Sellers's Hoisting-Machine.

firmly held by the chains *p* from contact with the conductor. *t* is a trigger which releases the cage in case of overwinding.

E is a factory-hoist like the modern elevator so much used in hotels. It is known in the North of England as a *teagle* (? *tackle*).

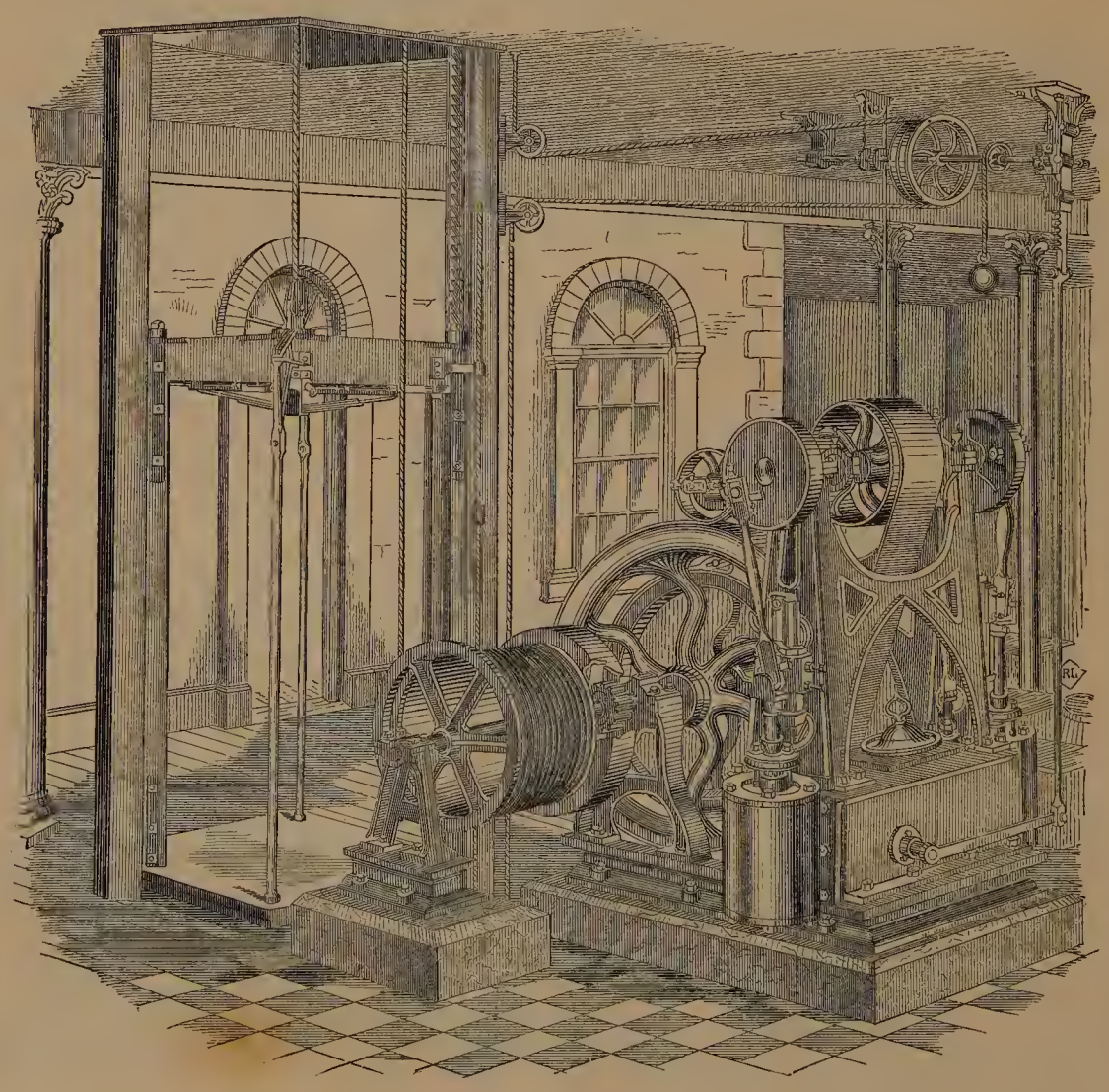
Sellers's hoisting-machine for warehouses or hotels is shown at Fig. 2529. It exhibits the wire-rope drum together with the up-and-down pulleys, and the middle loose pulley.

Fig. 2530 exhibits the hoisting-machine with the steam-engine by which it is driven. This is a double-cylinder, and reverses by a single movement of the valve-lever at the front. The platform moves at a speed of from 10 to 150 feet per minute, and has safety-ratchets which instantly lock it to the standards if the rope break. The drum on which the wire rope is wound has a spiral groove in which successive coils of the rope are kept separate. The car stops automatically at certain limits, or by hand at intermediate points. See ROPE-ELEVATOR.

See also under the following heads : —

Balance-crane.
Barton.
Block.
Bracket-crab.
Brake.
Brick and mortar elevator.
Bricklayer's hoist.
Bucket.
Cage.
Can-hook.
Cant-hook.
Capstan.
Cargo-jack.
Catadrome.
Cat-head.
Cat-tackle.
Check-hook.
Chevrette.
Chinese windlass.
Claw for suspending tackle.

Fig. 2530.

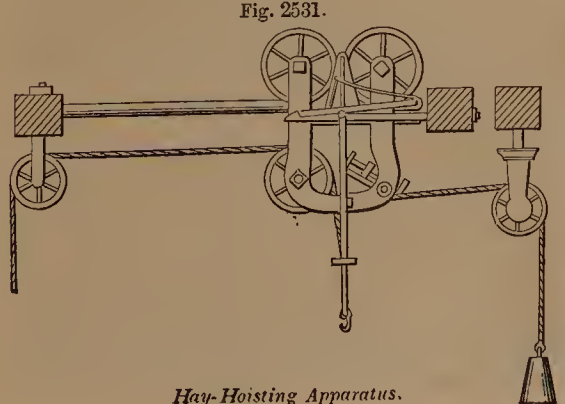


Miller's Hoisting-Machine.

Cog and round.
Cotton-elevator.
Crab.
Crampoons.
Crane.
Cuddy.
Davit.
Derrick.
Differential windlass.
Dolly.
Draft-engine.
Drop.
Drop-table.
Elevating-block.
Elevating-clutch.
Elevating-screw.
Elevator.
Field-derrick.
Fork.
Foundry-crane.
Furnace-hoist.
Gibbet.
Gin.
Gipsy-winch.
Glosso-comon.
Grain-elevator.
Gripe.
Hay.
Hay-loader.
Hod-elevator.
Hog-elevator.
Hoist.
Hoisting-apparatus.
Hoisting-boats.
Hoisting-machine.
Horns.
Horse-run.
Hydraulic crane.
Hydraulic elevator.
Hydraulic hoist.
Hydraulic lift.
Hydrostatic press.
Ice-elevator.
Inclined plane.
Jack.
Jeers.
Jib.
Jib-crane.
Jigger.
Lever-hoist.
Lewis.
Lift.
Lift-canal.
Lift-hammer.
Lifting-apparatus.
Lifting-jack.
Lifting-screw.
Loader.
Lock. Canal
Man-engine.
Masting-shears.
Mouline.
Movable ladder.
Needle.
Overhead-crane.
Parbuckle.
Plate-hoist.
Pneumatic hoist.
Portable derrick.
Pulley.
Purchase.
Rigger.
Rotary crane.
Sack-hoist.
Sack-lifter.
Safety-cage.
Sheer.
Sheer-hulk.
Sheers.
Side-winch.
Skid.
Sliding-pulley.
Slings.
Stacking-derrick.
Steam-crane.
Steam-hoist.
Steam-winch.
Stump-extractor.
Sweep.
Tackle.
Traveler.
Traveling-crane.
Traveling-derrick.
Traversing-elevator.
Triangle.
Water-crane.
Well-bucket elevator.
Whimsey.
Whin.
Whip.
Whip-crane.
Whip-windlass.
Winch.
Winding-engine.
Winding-tackle.
Windlass.

Among the modern facilities for taking care of farm produce, the horse hay-fork suspended by tackle from an elevated beam in the barn deserves a special mention. For the varieties of the fork, see Fork. This device is usually suspended by tackle from the beam by means of a clutch or tongs. (See Clutch.) The clutch, however, is not the only means of suspending the tackle and fork: in stacking hay a derrick is used, and in some barns a still more complicated device. When the load has reached its elevation, a pawl is raised which allows the carriage to traverse on the track and transport the load horizontally and return when the load is discharged. The brake moderates the rate of the hoisting-rope in running over the pulleys.

Fig. 2531.



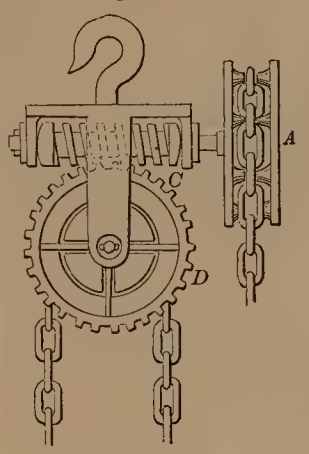
Hay-Hoisting Apparatus.

In another form of hoisting-machine, a platform, provided with rollers at its bottom, rests upon a large worm-wheel which meshes equally into two vertical worm-racks or segmental screws. Motion is imparted to the worm-wheel by a small gear-wheel meshing with a toothed rack on the lower surface of the worm-wheel.

Under this head may also be mentioned a device for lifting bricks, mortar, etc., to the top of buildings in course of erection. In this, buckets for the elevation of building material are fixed upon an endless chain. The chain is worked by a windlass at its upper end.

Hoist'ing-tack'le. A rope or chain and pulley used for hoisting. The simplest form of tackle is the *whip*, then follow the *whip-on-whip* and other forms of tackle cited in the list above. The form shown in Fig. 2533 is a differential tackle, and consists of two shafts, on each of which is a sprocket and a gear-wheel, the two latter meshing with each other. The proportion between the diameters of

Fig. 2532.



Worm-Wheel Tackle.

Fig. 2533.

Differential Hoisting-Tackle.

the gear and sprocket wheel on one shaft differs from the proportion between the diameters of the gear and sprocket wheels on the other shaft, in order that by overhauling the endless chain which is connected with the teeth of the two sprocket-pulleys, the block bearing the weight to be raised and connected by the chain with the sprockets may be raised or lowered as desired. The lower sprocket-wheel is applied so that it may be thrown out of connection with the upper one and locked so as to prevent retroaction.

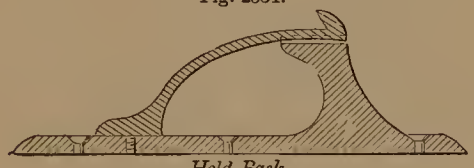
Fig. 2532 has a large wheel *A* on which is a worm *C* gearing into the chain-wheel *D*. Such a tackle will hold its load at any point at which the power ceases to be applied, and will not allow it to come down "on the run." The threads of a screw act as a stop or check to the windlass wheel.

Hold. (*Shipwrighting.*) The interior part of a

ship, in which the cargo of a merchant vessel or the provisions and stores of a man-of-war are stored. The portions are distinguished as the *fore*, *main*, and *after* holds.

Hold-back Hook. (*Vehicle.*) A projection on a carriage-shaft to which the breeching-strap of

Fig. 2534.



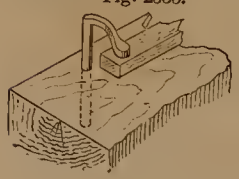
Hold-Back.

a horse is connected, to enable the animal to hold back the vehicle.

Hold-beam. (*Shipbuilding.*) One of those which support the lower deck in a merchantman; the *orlop* deck in a man-of-war.

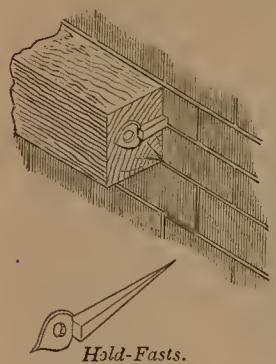
Hold-fast. A means by which something is clamped to another.

Fig. 2535.



The bench *hold-fast* is an arched bar, whose shank passes through a mortise in the bench, the *dog* pressing upon the work to be held. See BENCH-CLAMP.

A wall *hold-fast* is a spike, which is driven into the wall, and has a flat head through which a nail is driven into the object to be attached.



Hold-Fasts.

Hold'ing-down Bolt. (*Steam-engine.*) One of twelve or more strong bolts, which are passed from the outside of a steam-vessel through the floor-timbers, sleepers, foundation-plate of the engine, and the bosses on the cylinders, condensers, and side-frames, and are secured by strong nuts. The bolts are of copper or tinned iron, to resist the action of sea-water.

Hold'ing-up Ham'mer. A hammer held by the assistant against the head of the rivet while it is being riveted. See RIVETING.

Hole. A depression made to hold a blast.

Sinking, *boring*, *pumping*, *drilling*, are terms made use of.

Loading or *charging* the hole is the putting in of the powder.

Tamping is the packing of material upon the powder.

Hole-board. (*Weaving.*) See COMPASS-BOARD.

Hol'ing. 1. (*Mining.*) The under-cutting of coal by means of a pick wielded by a man lying upon his side. The making of vertical cuts at the sides is called *shearing*, and when these are made the stratum of coal is broken down by wedges driven in above.

2. (*Roofing.*) Piercing slates for holding nails.

Hol'ing-axe. A narrow axe for cutting mortises in fence-posts, for a *post-and-rail* fence.

Hol'land. (*Fabric.*) Linen or linen and cotton goods, white or self-colored, and with a glazed surface. Used for linings. As originally imported from Holland (whence its name), it was closely woven linen cloth.

Hol'low. A depression or unoccupied space, as—

a. The empty portion of a bastion.

b. The part of a cantle under the crupper-loop.

c. The gullet of a saddle under the pommel.

d. The depression in an anvil-face or fullering-tool used in forging round work.

e. A cavetto or recess bead in molding.

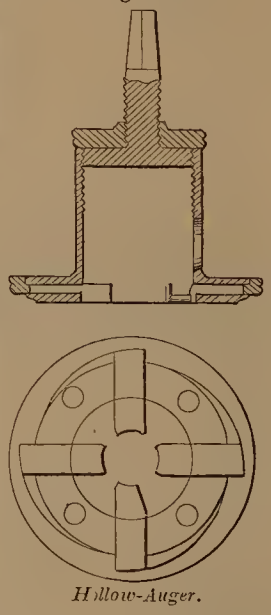
f. The seat of the shot in a counterbored gun. A *dent*.

Hol'low-adze. (*Coopering.*) A howel; a tool having a curved blade to chamfer the chine on the inside of a cask end.

Hol'low-au'ger. One for making round tenons in chair-work, on spokes, etc.

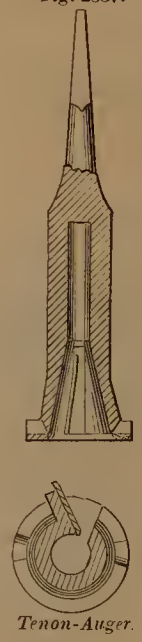
The end of the spoke or other piece of wood on which a round tenon is to be cut, is inserted into the tubular portion, whose throat has several radial rests and a radial cutter. The tool is revolved, and the blank is fed forward on the rests. The length of the tenon is gaged by the adjustable stop at the rear end of the tube.

Fig. 2536.



Hollow-Auger.

Fig. 2537.



Tenon-Auger.

Fig. 2537 is a form in which the auger cuts a tapering tenon and a shoulder upon the spoke simultaneously.

Hol'low-au'ger Bit. A wood-boring tool adapted to be used in a brace. It is of a hollow cylindrical form, and has cutters presented inwardly which make a cylindrical tenon on the end of the stuff. See HOLLOW-AUGER.

Hol'low-drift. 1. A tubular tool for driving a hole. See DRIFT.

2. A tool used in filling signal-rockets.

Hol'low-edge File. A file with a concave edge for dressing teeth of small gear wheels and pinions.

Hol'low-ing and Back'ing-ma-chine'. (*Coopering.*) A machine for rounding staves, giving the outer convexity and inner concavity.

Hol'low-ing-knife. (*Coopering.*) A drawing-knife for working on concave surfaces.

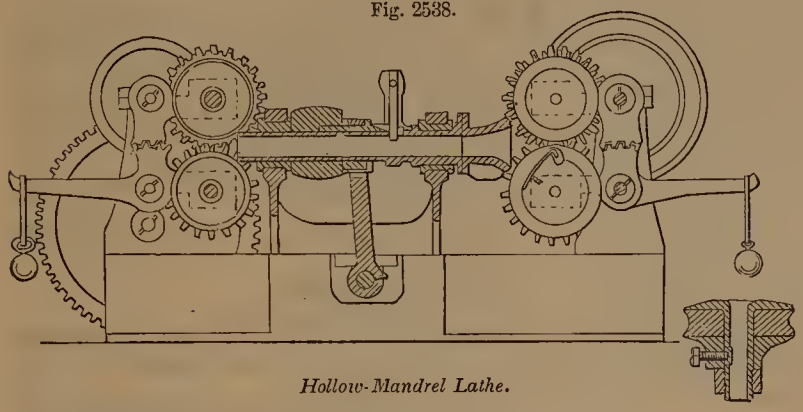
Hol'low-ing-plane. (*Carpentry.*) A plane with a round convex sole.

Hol'low-joint Wire. Small tubes employed in making joints, as in the casing of watches.

Hol'low-man'drel Lathe. One for small round stuff, such as broom-handles, scythe-snaths, stuff for clothes-pins, chair-rounds, round pickets, rails, etc. The stuff is fed by grooved rollers into the trumpet mouth of the revolving hollow mandrel. The tool

projecting from the internal periphery of the mandrel turns the blank into shape. The spring forms a stop for the strip, and its position indicates the time for its insertion berween the feed-rollers. The rollers which draw out the turned stick have circumferential depressions, which contain grooved annuli of rubber, which press with an adjustable force on the handle.

Fig. 2538.



Hollow-Mandrel Lathe.

Hol'low-new'el. The well-hole or opening in the center of winding stairs. *Open-newel*, in contradistinction to *solid-newel* or *corkscrew* staircase.

Hol'low-plane. A molding-plane with a convex sole. A *round-sole* plane.

Hol'low-punch. (*Saddlery and Shoemaking.*) The hollow punch is employed to make holes for rivets in leather; holes for eyelets in paper, leather, or fabric; holes for laces in shoes and stays, and on other occasions where a smooth, round hole is to be cut out of a yielding material. It is also known as an *eyeleting*-punch from its use as a means for punching holes for eyelets.

In a modified form, as the punch-pliers, it is used for punching cardboard tickets, tags, and papers for filing. A *ticket-punch.*

A *wad-cutter* is also a hollow punch.

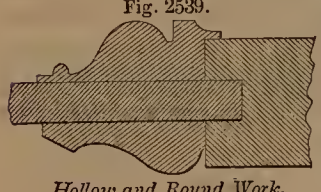
Hol'low-quoin. (*Hydraulic Engineering.*) One having a vertical recess for the hanging-post of a lock-gate to abut against.

Hol'low-rail. A tubular railroad rail, steam heated to prevent the accretion of snow and ice. Grime's English patent, 1831.

In Woodhouse's English patent, 1803, the rail forms a water-pipe.

Hol'lows and Rounds. (*Joinery.*) Concave and convex planes, respectively for working moldings. The illustration shows the use of *hollows and rounds*, in the molding of a panel door. They are made in pairs, and as many as eighteen pairs to a set.

Fig. 2539.



Hollow and Round Work.

Hol'low-ware. Cast-iron culinary vessels, such as pots, kettles, skillets, etc.

Ho-lom'e-ter. An instrument for taking measurements. See METER.

Hol'o-pho'tal Light. (*Optics.*) A name applied to such forms of lighting-apparatus for lighthouses as utilize the whole of the available light, by subjecting it all to the corrective action of the instrument; as, for instance, Thomas Stevenson's CATADIOPTRIC LIGHT (which see).

Hol-o-ster'ic Ba-rom'e-ter. One made of solid materials, so as to show variations of atmospheric pressure without the intervention of liquids.

The *aneroid* of Vidi, and the bent tube of Bourdon, are examples of *holosteric* barometers, but the word is sometimes used specifically to denote the former. The barometer constructed on the principle of the balance is described in Leupold. See BAROMETER.

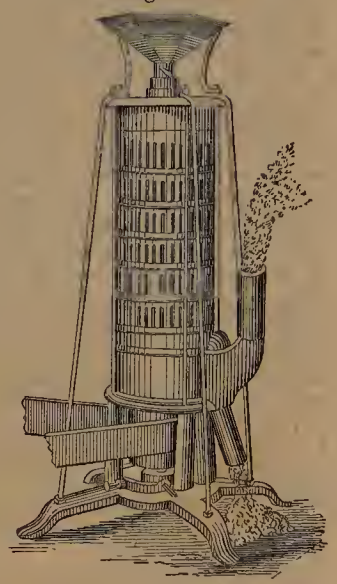
Hol'ster. 1. A leather case by the saddle-bow to hold a pistol.

2. A pistol-case carried on the person.

Ho'ly-stone. A large stone used with sand for scouring a ship's decks.

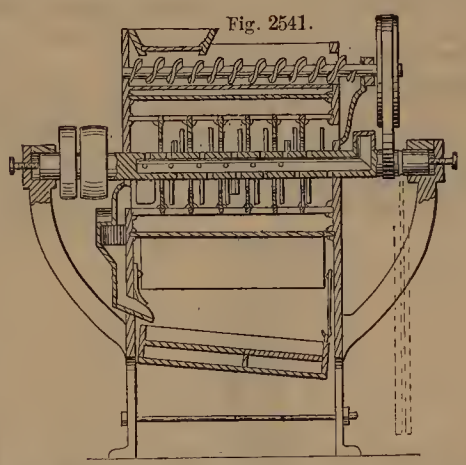
Hom'i-ny-mill. A machine in which shelled corn is subjected to a grating or beating action which removes the cuticle and the germ, and, by persistent and sufficiently energetic action may break the grain as small as may be wanted. The sizes are graded by sifting.

Fig. 2540.

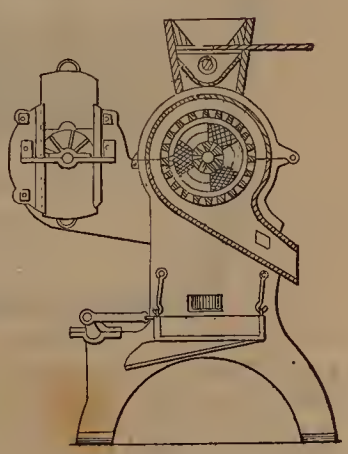


Vertical Hominy-Mill.

Fig. 2541.



In Fig. 2540 the corn is fed in above, and is subjected to the action of a series of beaters on the rotating vertical shaft. A fan in the case below blows out the dust, bran, and powdered germ.



Horizontal Hominy-Mill.

In Fig. 2541 the mill consists of a double case, the inner shell of which is provided with semi-annular plates or partitions. Within the case is a revolving hollow scouring and blowing shaft, having an air-gathering cup or scoop upon one of its ends, and at the opposite end is a discharge-spout and a blast-passage. Roughened scouring and smooth conveying blades are set spirally around the hollow blowing-shaft.

Hone. A flat slab, usually of some description of slaty stone, used for giving a keen edge to a cutting-tool after sharpening on the grindstone. Various kinds, differing greatly in texture and hardness, are employed. Norway ragstone, water-of-Ayr, bluestone, German-hone, and many other varieties, have a more or less extended reputation for their adaptation to special requirements, being used either dry or moistened with water or with oil. The *Turkey oil-stone*, which comes from Asia Minor, is generally known, and is employed for imparting an edge to chisels, plane-bits, and all the finer varieties of cutting-tools. It is usually cemented in a slab of wood and provided with a wooden cover.

The finest variety of stone suitable for hones is found in Arkansas, and is also known as Washita.

The metallic hone is a small round bar of steel, with fine longitudinal striations. For use it is moistened with oil and sprinkled with rottenstone or other fine abradant.

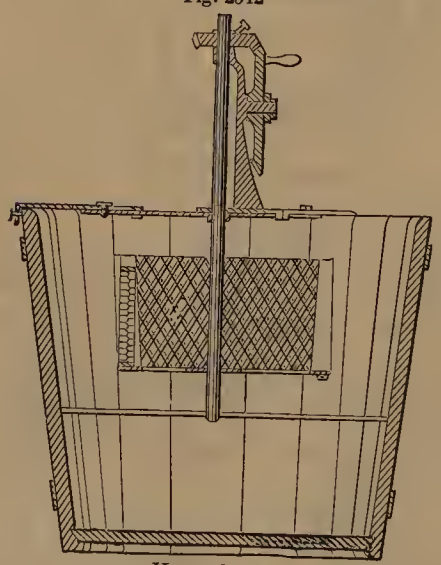
Fayrer's swing hone is a strip of brass pivoted at each end, so as to adjust itself to the edge of the razor. An abrading powder mixed with oil is applied upon one side, on which the razor is roughly sharpened, when the brass slip is turned and a keen edge imparted by the other side, moistened with a finer composition and oil.

Artificial stones and emery-charged leather are also used as hones. See GRINDING AND POLISHING.

Hon'ey-comb. A flaw in a casting.

Hon'ey-strain'er. A device for separating the honey from the comb. In a common form the comb is cut up and placed in a tub or tray to allow the honey to drain from the broken cells. In other cases it is pressed. The example is an application of the centrifugal filter to this purpose. After the

Fig. 2542



Honey-Strainer.

cap has been cut off the comb, it is placed in a wire-gauze basket which is rapidly rotated. The honey is thrown out by centrifugal force. The drained combs are returned to the hives to be again filled with honey.

Hon'i-ton-lace. (*Fabric.*) A variety of lace made by placing a perforated pattern upon a pillow, and then so twisting and interweaving the thread by means of bobbins, pins, and spindles, as to produce the required pattern.

Hood. 1. (*Mechanical.*) A dome-shaped projection or canopy over a discharging or receiving orifice in a structure, as of a fireplace, chimney, or ventilator.

A *cowl* over a chimney, ashore or aboard.

2. (*Wear.*) A soft covering which shrouds the head. Some are attached to a cloak. "With any that wears a *hood*." "A *cowled* monk."

3. (*Vehicles.*) A carriage-top which may be elevated or depressed.

4. (*Hydraulic Engineering.*) The capping of the piles of a starling.

5. The top of a pump.

6. The *companion* of a hatchway.

7. (*Nautical.*) *a.* A covering for a companion-hatch, scuttle, chain-pump, or skylight. A *cowl* for the galley chimney.

b. One of the foremost or aftermost planks of a strake. The *hood-ends* fit into the rabbets of the stem and stern posts.

8. (*Saddlery.*) The leathern shield in front of a wooden stirrup, which serves to protect the foot of the rider.

9. (*Sporting.*) The blinding cap on the head of a hawk to make him sit quietly on his perch. Said to have been invented by the Arabians.

Falconry was an ancient custom in Tartary; Ctesias, contemporary of Alexander the Great, mentions that hares and foxes were hunted in India by falcons. Aristotle speaks of the practice in Thrace. It was common in Italy in the time of Martial.

It attained its climax in Europe in the twelfth century.

Hood'ing-end. (*Shipbuilding.*) The end of a *hood* or endmost plank of a complete strake. The *hooding-ends* fit into rabbets of the stem and stern posts.

Hood-mold'ing. (*Architecture.*) A crown-molding. A *head*-molding.

Hood-quar'ter. (*Vehicles.*) One of the side pieces of the back portion of a hood.

Hoof-pad. (*Manage.*) A device attached to the hoof of a horse to keep the foot, or the shoe of the foot to which it is attached, from cutting the fellow foot or the fetlock. A device to prevent *interfering*.

Hoof-par'ing Knife. (*Farriery.*) A knife with a recurved blade, used for paring hoofs, to fit horse-shoes thereon; the sharply curved portion enables the knife to act as a *scorper* in the fissures between the *frog* and *sole*. See *g*, Fig. 2545.

Hoof-spread'er. (*Farriery.*) A device for expanding mechanically the hoof of a horse suffering from contraction of the foot.

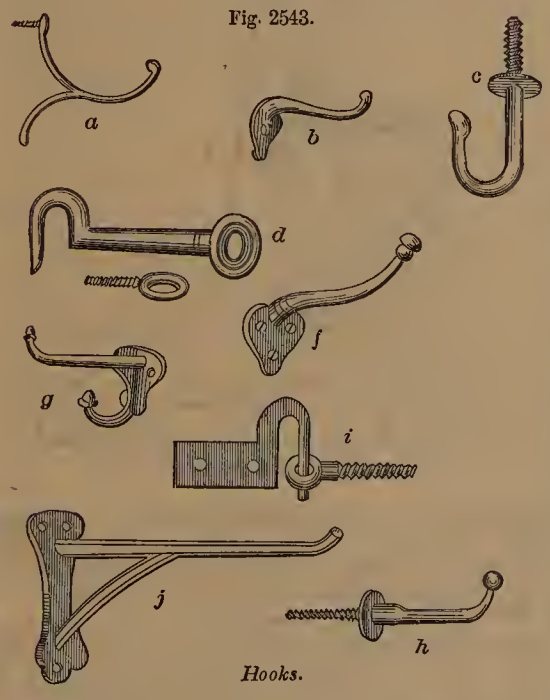
Hook. 1. A curved piece of metal (usually) by which an object is caught or suspended. A tool having a shape similar to the foregoing. See under the following list:—

Axle-hook.
Bench-hook.
Bid-hook.
Bill-hook.
Bloom-hook.
Boat-hook.
Boot-hook.
Breast-hook.
Button-hook.
Cambrel.
Can-hook.
Cant-hook.
Cat-hook.
Chain-hook.
Check-hook.
Chimney-hook.
Clasp-hook.
Clothes-line hook.
Clives.
Clove-hook.
Coat-hook.
Cotton-hook.
Cottrel-hook.
Creeper.

Crochet-hook.
Davit-fall hook.
Draft-hook.
Drag.
Dung-hook.
Eccentric-hook.
Fall-block hook.
Fire-hook.
Fish-hook.
Flesh-hook.
Fore-hook.
Gab-hook.
Gate-hook.
Grapple.
Grappling-hook.
Gullet-hook.
Harness-snap.
Hat-hook.
Heddle-hook.
Hog-hook.
Hold-back hook.
Hook and butt.
Hook and eye.
Hook-block.
Hook-bolt.
Hook-butt.
Hooked tool.
Hooking-frame.
Hook-motion.
Hook-rope.
Hook-scarf.
Hook. Sewing-machine
Hook-tool.
Hook-wrench.
Hose-hook.
Ice-hook.
Laying-hook.
Match-hook.
Meat-hook.
Mousing-hook.
Pad-hook.
Placenta-hook.
Plank-hook.
Pot-hook.
Pruning-hook.
Pulley suspension-hook.
Rack-hook.
Reaping-hook.
Safety-hook.
Sewing-machine hook.
Shave-hook.
Sheep-hook.
Shell-hook.
Shutter-hook.
Sister-hook.
Snap-hook.
Spring-hook.
Suspension-hook.
Tackle-hook.
Tenaculum-hook.
Tenter-hook.
Tow-hook.
Trace-hook.
Wad-hook.
Watch-chain hook.

Besides these are many which come under the

Fig. 2543.



Hooks.

name of hardware, and whose names indicate their purpose : —

Awning-hook.
Bird-cage hook.
Cabin-door hook.
Clothes-hook (*f a b c*).
Cotton-hook.
Dressing-glass hook.
Harness-hook (*j*).
Head-board hook (*i*).
Hook and eye (*d*).
Horse-hitching hook.
Lamp-hook.
School-house hook.
Screw-hook (*h*).
Wardrobe-hook (*a b c*).

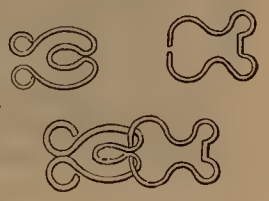
2. (*Shipbuilding.*) A knee or strengthening frame conforming to the inner shape of the vessel and supporting the bow or forward ends of the decks. See STEM.

3. (*Knitting-machine.*) The barbed extremity of the needle, which retains the yarn. The *beard*.

Hook and Butt. A mode of scarfing timber so that the parts resist tensile strain to part them. A *hook-scarf*. See SCARF.

Hook and Eye. An ordinary fastening of ladies' dresses. Made of flattened wire and bent to form, as in the example.

Fig. 2544.



Hook and Eye.

Hook-block. A pulley-block strapped with a hook, in contradistinction to one with an *eye* or a *tail*. See cut of BURTON.

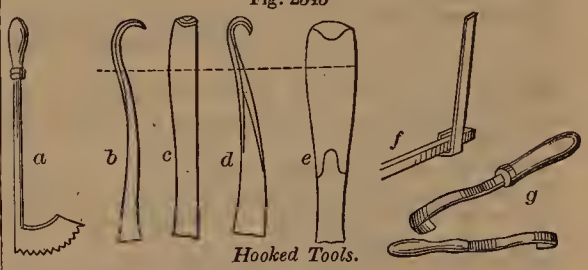
Hook-bolt. A bolt with a hook-head. Used on board ship to fasten lower-deck ports.

Hook-butt. (*Carpentry.*) A mode of scarfing timber. See SCARF.

Hooked-bolt. One with a lip used to fasten boards on to a ship's frame or a wharf.

Hooked-tool. 1. A marble-worker's chisel (*a*),

Fig. 2545



Hooked Tools.

the end bent to a right angle, and used in positions where the square chisel cannot be readily employed.

2. Wood-turning tools of the nature of scorpers (*b c d e*).

3. A bent iron rod (*f*) forming three sides of a square, one end being prolonged for a handle. Used in *taking the twist out* of a bar while forging.

4. A hoof-paring knife (*g*).

Hook'er. (*Nautical.*) A one-masted merchant vessel of the English and Dutch waters. A *howker*.

Hooke's Gear'ing. A kind of gearing in which the teeth are somewhat obliquely across the face of the wheel, so that the contact of each tooth commences at its foremost end and terminates at the aftermost end ; the *pitch* of the spiral is such that the contact of one pair of teeth does not terminate until that of the next pair has commenced.

Hooke's stepped gearing is of a somewhat similar design.

Hooke's Joint. A universal joint. A GIMBAL-JOINT (which see).

Hook'ing-frame. A frame with hooks upon which cloth is measured and suspended, being folded back and forth until the required quantity is reached, when it is cut off and removed to be packed.

Hook-mo'tion. (*Steam-engine.*) A valve-gear having hooks for actuating and reversing.

Hook-rope. (*Nautical.*) One six or eight fathoms long, with a hook and thimble spliced at one end and whipped at the other. It is used to drag chain and for similar purposes.

Hook-scarf. (*Carpentry.*) A mode of fastening timbers together endways, so that they lock to each other. See SCARF.

Fig. 2546.

Hooking-Frame.

Hook-tool. (*Lathe.*) *a.* A form of hand-tool used in metal turning, which is of a hook shape, and is supported on a rest below and beyond which it extends. A HANGING-TOOL (which see).

b. A wood-turning tool having a bent portion used for bottoming boxes, or lids, or other hollow work. See Fig. 2545.

Hook-wrench. A form of spanner which has a bent end adapted to grasp a nut or coupling piece and turn it. See Fig. 2545.

Hoop. 1. (*Coopering.*) A strip of metal or wood united at the ends and driven around a cask to hold the staves together.

Hoops for casks are known as: —

Bulge-hoop; the hoop nearest the swell of a cask.

Chine or *chime* hoop; or *head*-hoop; the hoop nearer to the end or *chine*.

Flat-hoop; a thin hoop; flat on both sides.

Half-round hoop; a hoop whose outside is the undressed exterior of the pole.

Quarter-hoop; an intermediate hoop between the bulge and chine.

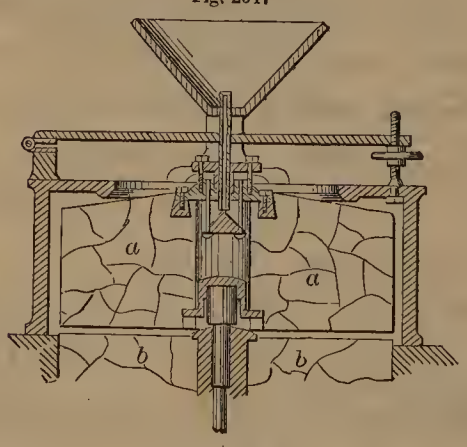
Truss-hoop; a stout hoop of wood, used before or preliminary to the final hooping.

2. (*Nautical.*) *a.* One of the rings to which the *weather-leach* of a *fore-and-aft* sail is bent, and by which it slides on the *mast* or *stay* as the sail is hoisted or lowered. A *hank*.

b. A band on a wooden anchor stock.

3. (*Milling.*) *a.* The enclosing case of a run of stones. It stands on the husk. *a* is the runner, *b* the bed-stone.

Fig. 2547



Grinding-Mill.

b. A metallic band around a mill-stone.

4. A strap around an eccentric.

5. (*Apparel.*) *a.* A thin strip (usually of steel and covered with braid), used in expanding the skirts of ladies' dresses.

b. A frame made of pliable, steel, braid-covered hoops, united by vertical tapes and adapted to expand the skirt of a lady's dress. Frames of similar shape but differently constructed were in use in the time of Pope and of Queen Bess.

Hoop-bend'ing Ma-chine'. (*Coopering.*) A machine for curving hoops; generally consisting of a set of three rollers between which the hoop is passed, the upper roller acting against and between the two lower ones, and having its lower surface depressed below the upper line of the two lower ones.

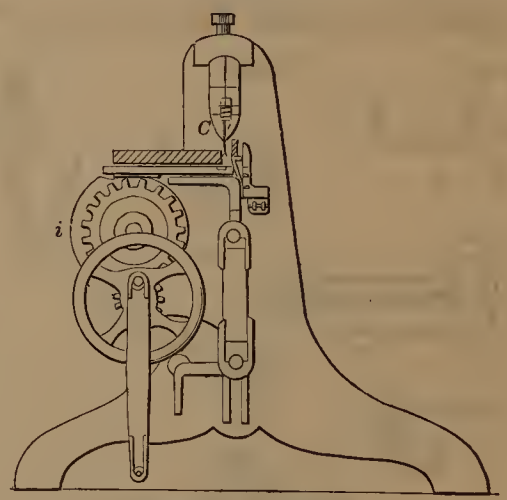
Hoop-coil'ing Ma-chine'. (*Coopering.*) A machine by which split, sawn, or cut hoop-stuff for barrels is wound upon a drum so as to be secured in a coiled condition for shipment and use.

Hoop-cramp. (*Coopering.*) A ring-clutch for holding the ends of a hoop which are lapped over each other.

Hoop-crimp'ing Ma-chine'. (*Coopering.*) One for giving the bend to hoop-stuff to render the hoops tractable in fitting to barrels and casks.

Hoop-cut'ting Ma-chine'. (*Coopering.*) One for cutting from the log or from the edge of a board a slat for a hoop. When made from the log, the latter is rotated between each cut, and the knife makes an incision a depth equal to the width of the hoop, which is removed by another cutter. In cut-

Fig. 2548.



Hoop-Cutting Machine.

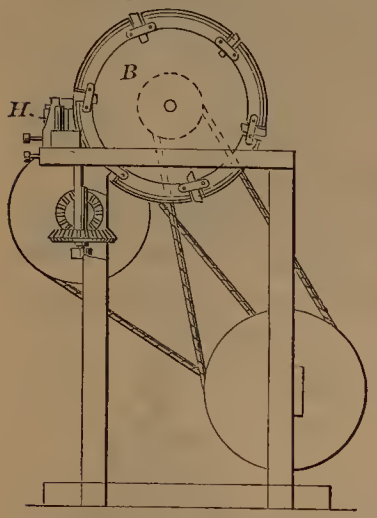
ting from a board, a reciprocating knife *C* cuts hoops from the edge of a plank resting on a table which is alternately raised and lowered by a cam *i* to impart an edgewise taper or bevel to the hoops.

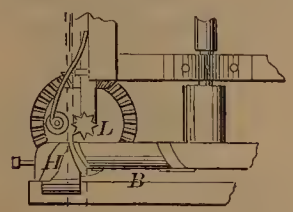
Hoop-dress'ing Ma-chine'. (*Coopering.*) A machine for dressing rived hoops to an even thickness. In the example, the hoops are dressed by means of a revolving cutter-wheel, in connection with a guide-block and pressure and feed roller. The lower part of the figure shows the operation more in detail, the hoop passing between the rotary cutter *B* and the head-block *H*. *L* is the feed-roller.

Hoop-driv'er. (*Coopering.*) *a.* A hand-tool which is rested on the edge of the hoop and beaten by a hammer or mallet to force the hoop on to the cask.

b. A machine by which the hoops are forced on simultaneously.

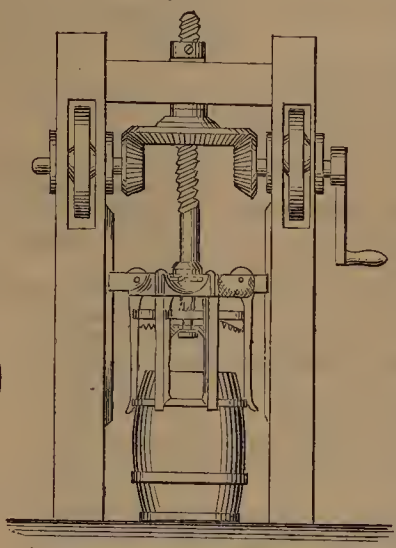
Fig. 2549.





Hoop-Dresser.

Fig. 2550.



Hoop-Driving Machine.

Attached to a screw-shaft revolved by gearing is a head to which are pivoted pendant drivers, which are adjusted to the side of the cask by a cam-disk with projections on the periphery that force the drivers outward as it is turned, and by revolving the screw-shaft, the head is depressed and drives the hoops upon the cask.

Hoop'ing. (*Founding.*) The iron-work around a molding-box.

Hoop-iron. Flat, thin bar-iron.

Hoop-lock. 1. (*Coopering.*) *a.* A mode of connecting the ends of the split pole or slat which forms a hoop.

b. One of the interlocking notches near the ends of a barrel-hoop.

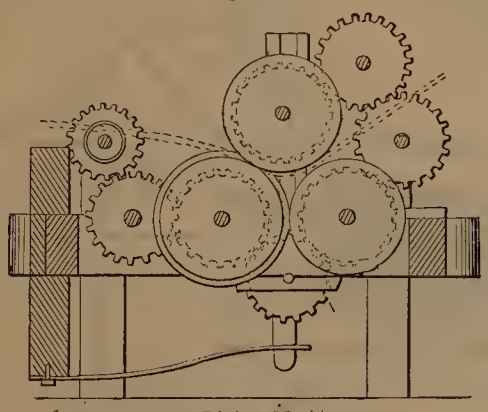
Machines are made for cutting hoop-locks, having descending cutters shaped to the curved form of the notch required.

2. A fastening for the ends of hoops; used in baling hay or cotton. See BALE-TIE.

Hoop-plan'ing Ma-chine'. (*Coopering.*) A machine for thinning down and dressing the surface or surfaces of hoop-pole stuff, or of stuff sawed or cut for hoops. See HOOP-DRESSING MACHINE.

Hoop-punch'ing Ma-chine'. (*Coopering.*) A machine for punching rivet-holes in iron hoops for casks.

Fig. 2551



Hoop-Riving Machine.

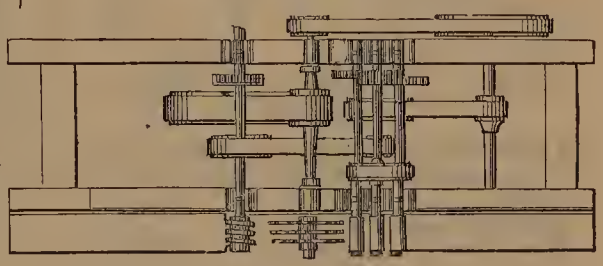
Hoop-rack'ing Ma-chine'. (*Coopering.*) One for forcibly bending rived hoops to make them tractable in placing them around casks.

Hoop-riv'ing Ma-chine'. (*Coopering.*) A machine in which the bar of wood to be rived is sawed out of a proper width for the hoop required, and the end checked by a gang of circular saws. The end is then placed between the guiding friction wheels and advanced to the groove of the wheel, where it is seized by the bite of the upper pressure disk, and passing along is deflected upwards by another wheel emerging from between the latter wheel and the upper disk in a riven condition.

Hoop-saw'ing Ma-chine'. (*Coopering.*) *a.* A machine in which gaged stuff is fed to a gang of circular saws and reduced to dimensions for making hoops. In the example, the saw-shaft has journal bearing either above or below the guide-rollers. The guide-rollers are kept in their journals by pins traversing the upwardly projecting sides of the said journals.

b. A machine which removes, by successive actions, a thin strip for the edge of a board.

Fig. 2552.

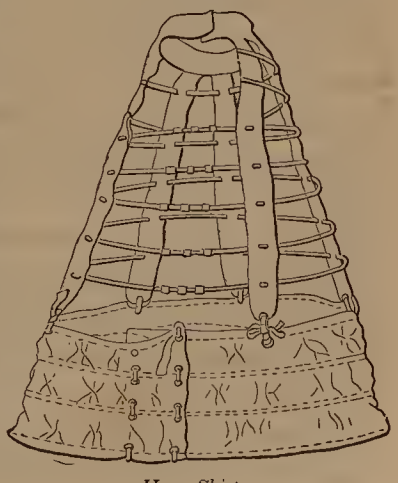


Hoop-Sawing Machine.

c. A machine which saws hoops from a log, which is rotated between each cut, the thickness of a hoop plus the kerf; the saw cutting down into the log the width of a hoop, and a second saw or a cutter removing the hoop so cut.

Hoop-shav'ing Ma-chine'. (*Coopering.*) One for reducing the thickness of hoop stuff, and dressing the edge which lies against the cask. See HOOP-DRESSING MACHINE.

Fig. 2553.



Hoop-Skirt.

Hoop-skirt. The fardingale of the time of Queen Elizabeth. See also the "Tatler," January 5, 1710.

The modern hoop-skirt is formed of braid-covered flat steel-wire hoops, united by tapes and shaped upon a former. Various ingenious devices are adopted for making, tempering, covering, marking, and sizing the wire, for clasping the *spanglcs* which unite the tapes and wires at their interseetions.

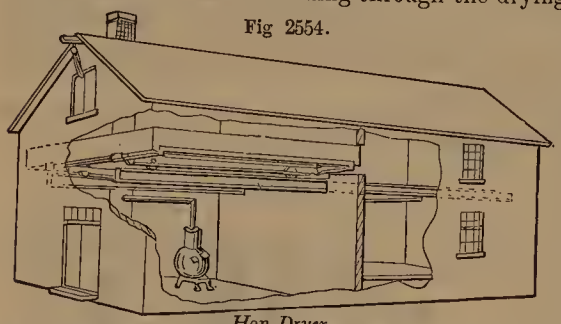
Hoop Splay'ing and Bend'ing Ma-chine'. (*Coopering.*) A machine for spreading hoop-iron on one side so as to enable it to set snugly on the bilge, and at the same time bending the hoop to the curve of the cask.

Hoop-split'ting Ma-chine'. (*Coopering.*) A machine to rive hoops from stuff properly prepared. See HOOP-RIVING MACHINE.

Hop-back. (*Brewing.*) The vessel beneath the copper which receives the infusion of malt and hops, and has a perforated bottom which strains off the hops from the unfermented beer.

Hop-dry'er. A chamber in whieh hops are artificially dried. In the example, a tilting drying-frame runs on a track extending through the drying

Fig 2554.



Hop-Dryer.

and store rooms, so that the hops, after drying above the furnace in the former room, may bc deposited in the latter.

Also called an *oast*, or *hop-kiln.*

Hop-frame. (*Agriculture.*) A trellis on which hops are supported while growing. Hops are usually grown on poles, whieh are pulled out of the ground and laid aeross trestles for the eonvenience of the hop-pickers. Hop-frames are some of them made to recline to bring them within reach of the piekers.

Hop'per. 1. (*Machinery.*) A ehute for feeding any material to a maehine. It is generally of an inverted frustal shape, as in brick-maehines for feeding elay to the pug-mill; in winnowing-machines, for feeding the grain and chaff to the upper riddle; in grinding-mills, for feeding grain to the stones. Its name is derived from the latter, as it used to be shaken by a *damsel* (projection) on the spindle, in order to keep the grain fed down into the throat. It now feeds the grain into a shaking *shoe*, which is agitated by the *damsel*. See GRINDING-MILL.

The term is also applied to the reservoir which contains the grain in seeding-machines, planters, drills, etc.

The term is also applied to a feeder, such as the fuel reservoir of a stove.

The holder of blanks in a machine, as the serew-blanks in a screw-cutting machine. The planchets in a coining-machine, eyelets or spangles in machines nsing those articles, and many others too numerous to mention.

2. The basin of a water-closet.

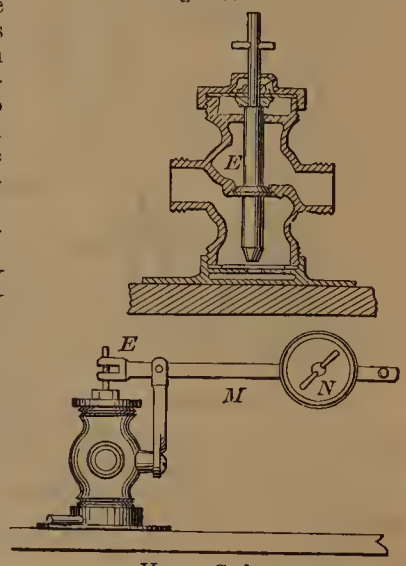
3. (*Glass.*) A conieal vessel suspended from the ceiling, containing sand and water for the use of the glass-cutter.

4. (*Music.*) A jointed, upright piece attached to the back of a key in a piano-forte movement, to lift the hammer, instead of the stiff wire or lifter used formerly. It is an arrangement for allowing the key to impel the hammer and then eseape from it, so that the hammer is free to fall away from the string immediately. It is a feature of the *double-action* piano-forte movement. See PIANO-FORTE.

Hop'per-boy. A device in a grinding-mill, eonsisting of a revolving rake drawing the meal over a discharge opening in the floor. Invented by Oliver Evans.

Hop'per-cock. A valve for water-closets, etc. In the example, pressure on the seat depresses the stem *E* with its valve, allowing the water to pass through and out of the opposite eduction opening. When the pressure is relieved the weight *N* on the lever *M* attached to the rod *E* lifts the valve again into its seat.

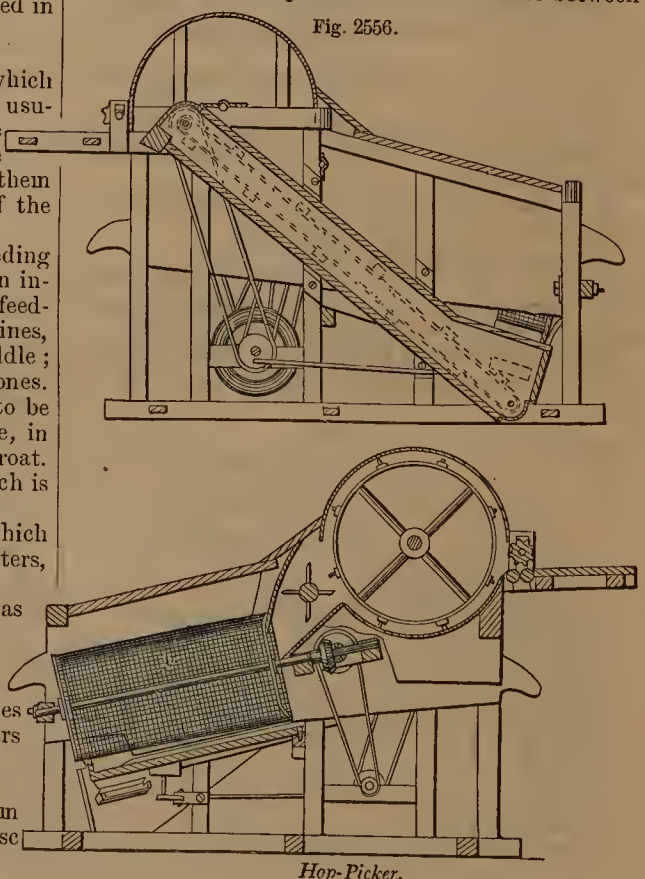
Fig. 2555.



Hopper-Cock.

Hop-pick'er. (*Husbandry.*) A maehine for pieking hops. The branches are stripped from the vines and passed into the machine between

Fig. 2556.



Hop-Picker.

the feed-rollers, when they encounter the teeth of the picker, which detach the hops from the vines and pass both through the trough into the screen, wherefrom the hops drop into the shaker, whence they are conveyed by the elevator to sacks.

The figures are respectively a side elevation and longitudinal vertical section.

Hop'ple. (*Menage.*) A device for confining the legs of horses so as to hamper their motion and thus restrain their wandering. A *hobble.*

The devices are principally modes for shortening their step and thus reducing their speed, as well as lessening their inducement to stray, owing to the inconvenience of motion and unaccustomed restraint.

a is one intended for training. The pads are strapped around the pastern and above the knee respectively, and are connected to each other by a rubber band rove through a staple on the upper pad, and regulated as to length by the buckles on the lower pad.

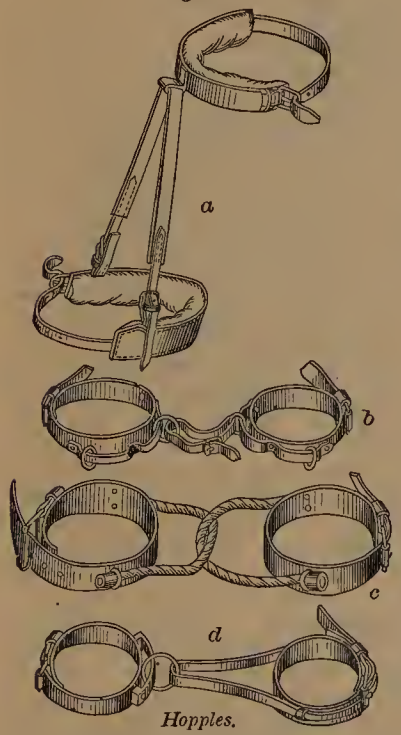
b is Captain Eagle's hopple, in which the coupling-strap ring moves in staples in the fetlock straps, and does not tend to rotate the latter and thus gall the limb.

c has coupling-loops which divide the abrasive motion between them.

d has a strap which slips through the ring instead of turning the leg-band.

Hop-pole. (*Husbandry.*) A training-pole for hops. It consists of little but a simple sapling or trunk of one of the lighter trees, the wood depending upon the means and kinds at hand.

Fig. 2557.

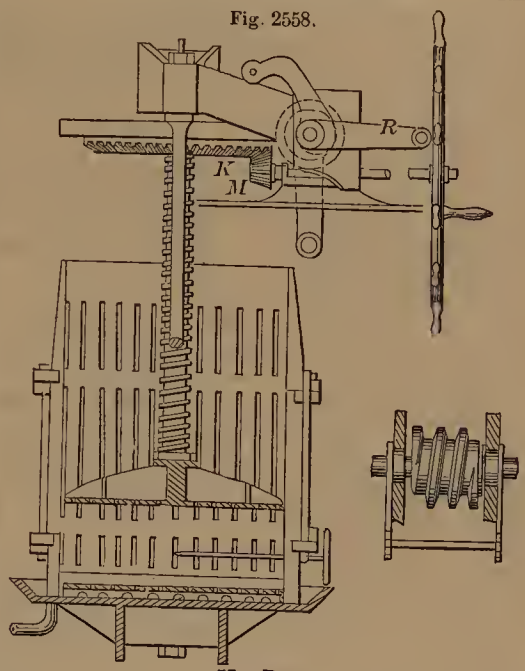


Hopples.

Hop-press. (*Brewing.*) A machine for expressing the liquid from hops after boiling.

In the press shown, a rapid rotation of the screw in the early part of the operation is obtained through the bevel gear *K M* by turning the hand-wheel. When the resistance becomes great, the hand-wheel is thrown out of gear and a worm-wheel connected, which by turning cranks *R* gives a slow but powerful impulse to the screw.

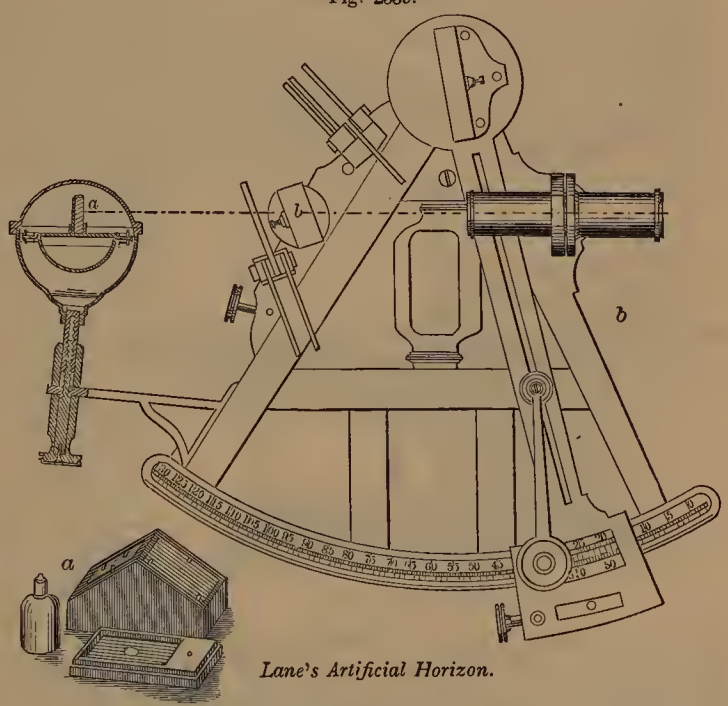
Fig. 2558.



Hop-Press.

Ho-ri'zon, Ar-ti-fi'cial. (*Optics.*) A rectangular platform (*a*, lower figure), with raised sides, and legs arranged for leveling. A glass roof protects the mercury, which is poured upon the platform and forms the horizon.

Fig. 2559.



Lane's Artificial Horizon.

Lane has a method of determining the artificial horizon for sextants, etc. To a sextant *b* of the usual construction, with an index-glass, horizon-glass, and eye-piece, is added a vertical mirror or reflecting surface *a*, the plane of which is perpendicular to a continuation of the visual ray passing from the eye-piece and intersecting a hair-line *b*, or its equivalent, which is placed in the frame of the horizon-glass, or at any point between the mirror *a* and the eye, where it can be seen by the latter, with or without the aid of a lens.

The plane of the horizon is a tangent to the cur-

vature of the earth at any place, and is assumed very nearly by the surface of a quiescent liquid, which thus becomes an artificial horizon from which the altitude — of a heavenly body, for instance — may be measured. From the law of the reflection of light, it follows that the angle subtended at the eye of an observer by a star and its image as seen reflected from such a liquid surface is twice that of the altitude of the star above the horizon. On account of its high reflecting power, mercury is the liquid generally used for an artificial horizon.

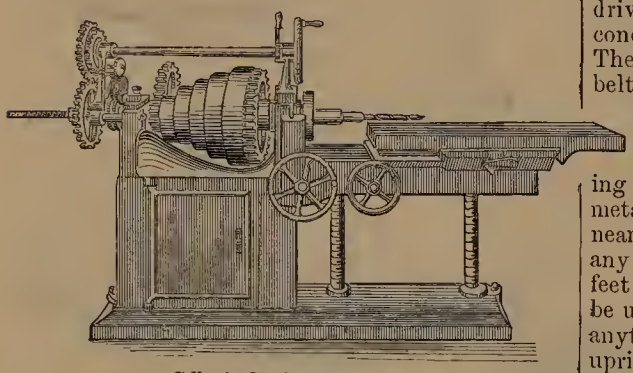
A horizontal spinning speculum was adopted by Lerson, of England, and this was improved by Smeaton, who used a polished metallic speculum about three and a half inches in diameter enclosed in a circular rim of brass, so fitted that the center of gravity of the whole shall fall near the spot on which it spins. This is the end of a steel axis running through the center of the speculum, above which it finishes in a square for the convenience of fitting a roller on it, bearing a piece of tape wound round it. It spins in an agate cup.

Ho-ri'zon-glass'es. (*Optics.*) The two speculums on one of the radii of a quadrant or sextant. The one half of the fore horizon-glass is silvered, while the other half is transparent, in order that an object may be seen directly through it. The back horizon-glass is silvered above and below, but has a transparent stripe across the middle, through which the horizon can be seen.

Hor-i-zon'tal Di'al. One with a plane parallel to the horizon, having its gnomon elevated according to the latitude of the place.

Hor-i-zon'tal Drill. (*Machinery.*) A boring-machine whose drill-arbor works horizontally and parallel with the bed to which the work is dogged. It has variable feed and quick hand traverse to boring-spindle, arranged so as to be changed instantly from

Fig. 2560.



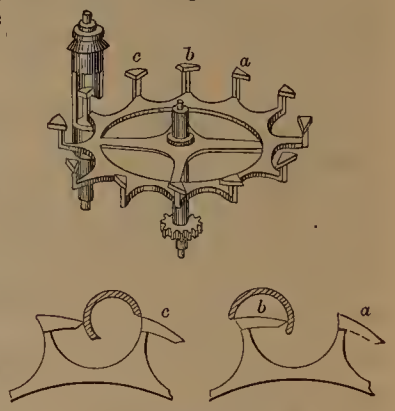
Sellers's Horizontal Drill.

one to the other; compound tables arranged to move vertically, with horizontal movement at right angles and parallel to drilling-spindle; the arbor which carries the drilling-spindle is arranged with face-plates, so that the machine can be used as a face-lathe.

Hor-i-zon'tal Es-cape'ment. One in which the impulse is given by the teeth of a horizontal wheel acting on a hollow cylinder on the axis of the balance. It was invented by Graham, about 1700.

The diagram shows the action, the cylinder being represented in two positions at different portions of its oscillation. The pallets *a b c* on the wheel rest alternately on the inside and the outside of the cylinder, their beveled edges sliding against the edges of the cylinder, to communicate an impulse thereto. It is a *dead-beat* escapement. There is considerable friction. The parts are delicate and hard to repair. The cylinder has been made of a ruby, but at great expense.

Fig. 2561.



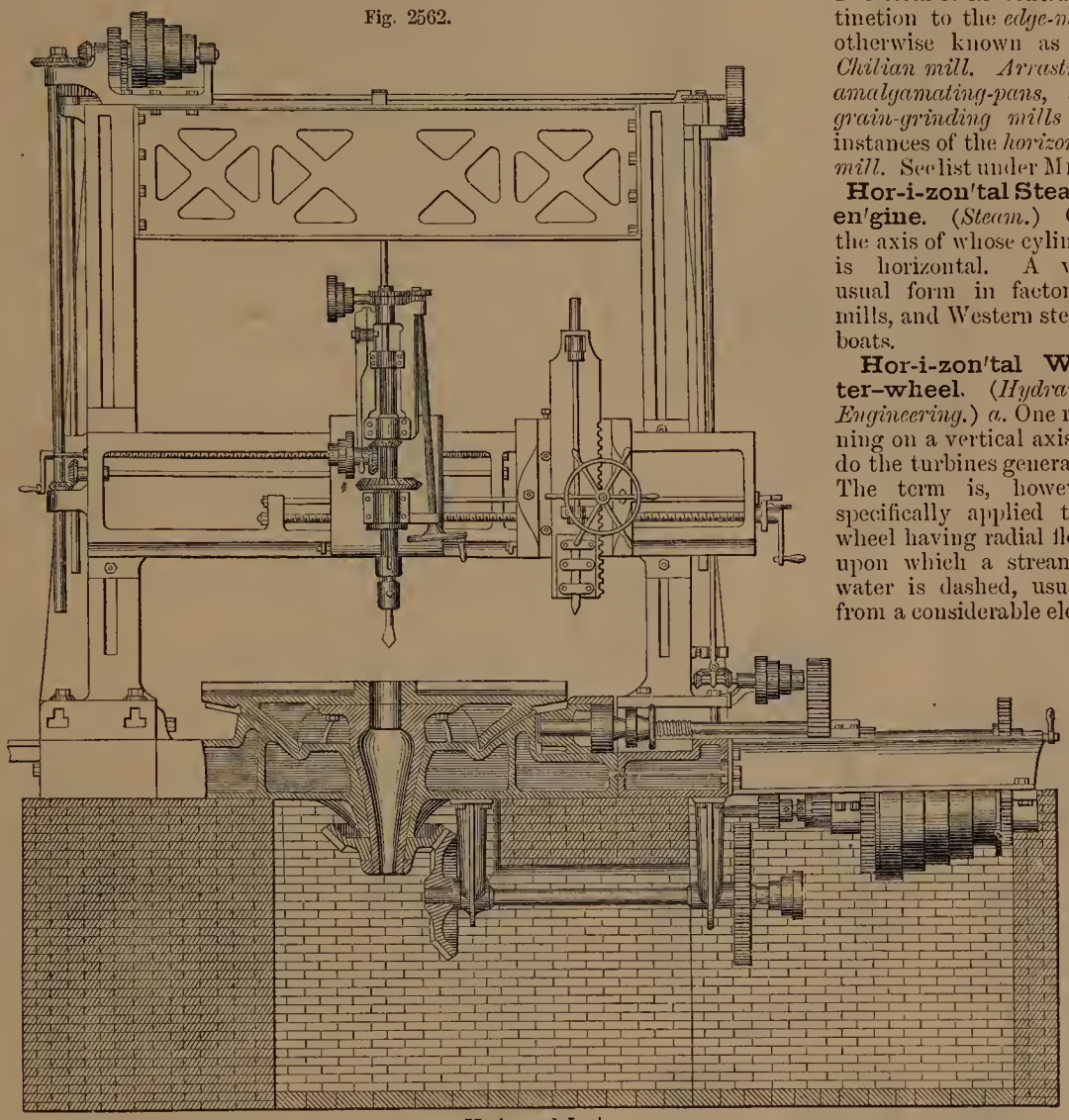
Horizontal Escapement.

Hor-i-zon'tal Lathe. A *vertical turning and boring machine.* The one illustrated is set up in the Boston Navy-Yard, and is, perhaps, the largest in use, being of such a size that a monitor turret can be turned in it entire. The work-table, instead of traveling in slides, is circular, and revolves like a face-plate on a vertical axis. The tools are held in heads on a cross-slide, which is fitted to two uprights resting on cheek-pieces bolted to the main casting or foundation-piece.

On the under side of the revolving table is a bevel-gear driven by a pinion, which may be backed out of gear by means of a hand-wheel on a thread on the horizontal shaft. The hub of this pinion, being slightly larger in diameter than the pinion itself, is used as a journal, by means of which the pinion is caused to revolve with great steadiness, and when out of gear the pinion is within the pillow-block. This is required when a quick motion is given to the table by means of a pair of miter-gears, one of which is attached to the lower end of the table-bearing. One of the heads on the cross-slide is fitted for drilling, the spindle being 4½ inches diameter, with a travel of 18 inches, independent of the cross-slide. This drill-spindle is driven by means of miter-gears and shafting from a cone placed on the top of the upper cross-brace. The revolving table is driven by means of a 6-inch belt running on a 5-speeded cone, the smallest pulley of which is 17 inches diameter, the largest 34 inches, strongly back-geared in such manner as to allow 20 different speeds. The conical bearing of the revolving table is lined with Babbitt metal. By placing the uprights with cross-slide near the revolving table, the drill may be placed at any point within the surface of a diameter of 12 feet; while in the same position the other head may be used for the purpose of boring, facing, or turning anything of the same size. By moving back the uprights near the ends of the cheek-pieces the machine is capable of boring, facing, or turning anything up to 24 feet diameter. The main casting, in which the table revolves, is 10 feet 4 inches square by 24 inches deep, except at the center, where a projection receives the lower end of the bearing; at this point it is 9½ inches deeper. This casting weighs 26,000 pounds; weight of circular table, 13,000; weight of the cheek-pieces on which the uprights move, 14,000 pounds each. These pieces are 21 feet long, 24 inches high, 3 inches wide; the cross-slide 15 feet long, 33 inches high, deepest part of arched back 22 inches. This is cast hollow. The two uprights are connected at their upper ends by means of a cross-brace 11 feet 4 inches long by 36 inches deep. The tool-holder slide weighs 1,000 pounds, and is fitted with rack and pinion for quick movements, and screw for self-feed. The cross-slide is raised or lowered by means of screws and worm-wheel driven by power. The uprights, with the

cross-slide, may also be moved to and fro on the cheek-pieces by means of power applied to screws working in nuts at their lower ends.

Fig. 2562.



Horizontal Lathe.

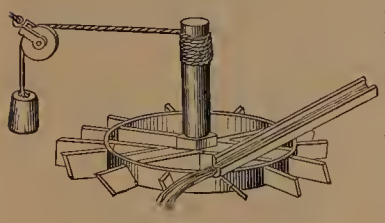
Hor-i-zon'tal Mill. A mill in which the acting surfaces are in a horizontal plane at right angles to the vertical axis of the rotating stone or stones. The term is in contradistinction to the *edge-mill*, otherwise known as the *Chilian mill*. *Arrastras*, *amalgamating-pans*, and *grain-grinding mills* are instances of the *horizontal mill*. See list under MILL.

Hor-i-zon'tal Steam-en'gine. (*Steam.*) One the axis of whose cylinder is horizontal. A very usual form in factories, mills, and Western steamboats.

Hor-i-zon'tal Wa'ter-wheel. (*Hydraulic Engineering.*) *a.* One running on a vertical axis, as do the turbines generally. The term is, however, specifically applied to a wheel having radial floats upon which a stream of water is dashed, usually from a considerable elevation. The floats may be set spirally, so as the better to receive the impact of the water.

This form of wheel has but little prominence in this country, but is used in Central America and some other places where a small body of water with a considerable head is available, and the mechanical appliances at hand will not furnish a better arrangement.

Fig. 2563.



Horizontal Water-Wheel.

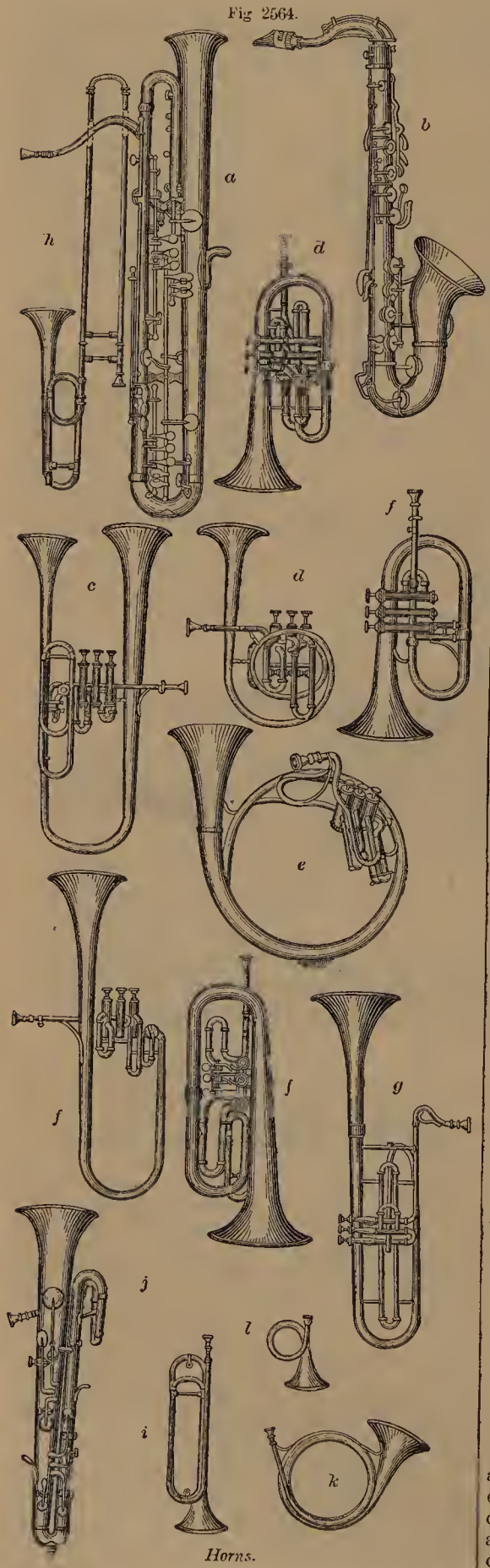
b. A *turbine*, as it is usually arranged.

Horn. 1. A hard projection from the heads of certain animals, cattle, sheep, and goats. Mechanically and chemically speaking, the *horns* of these animals must not be confounded with the antlers of the various species of deer, which are more nearly allied to bone and ivory. The finer varieties of horn have but 2 or 3 per cent of earthy matter, while bones have over 50 per cent. If we seek for other articles nearly allied to true *horn*, we shall find them in tortoise-shell, hoofs, claws, nails, quills, whalebone.

The bony core of the horn being removed, the next process is to cut off with a saw the tip of the horn, that is, the whole of its solid part, which is used by the cutlers for knife-handles, is turned into buttons, and is applied to sundry other purposes. The remainder of the horn is left entire or is sawn across into lengths, according to the use to which it is destined.

Next, it is immersed in boiling water for half an hour, by which it is softened; and while hot is held in the flame of a coal or wood fire, taking care to bring the inside as well as the outside of the horn, if from an old animal, in contact with the blaze. It is kept here till it acquires the temperature of melting lead or thereabouts, and in consequence becomes very soft. In this state it is slit lengthwise by a strong pointed knife like a pruning-knife, and by means of two pairs of pincers, applied

Fig 2564.



Horns.

one to each edge of the slit, the cylinder is opened nearly flat.

The degree of compression is regulated by the use to which the horn is afterwards to be applied ; when it is intended for leaves of lanterns, the pressure is to be sufficiently strong (in the language of the workmen) to break the grain ; by which is meant separating in a slight degree the laminæ of which it is composed, so as to allow a round-pointed knife to be introduced between them in order to effect a complete separation. The plates are laid one by one on a board covered with hide, and being fastened down are scraped with a draw-knife ; when reduced to a proper thickness and smoothed, they are polished by a woolen rag dipped in charcoal dust, adding a little water from time to time ; they are then rubbed with rottenstone, and polished with horn shavings.

For combs, the plates of horn should be pressed as little as possible, so that the teeth may not split at the points. They are shaped chiefly by means of rasps and scrapers of various forms, after having been roughed out by a hatchet or saw ; the teeth are cut by a double saw fixed in a back, the two blades being set to different depths, so that the first cuts the tooth only half-way down, and is followed by the other which cuts to the full depth ; the teeth are then finished and pointed by triangular rasps. Articles too large to be made from a single plate of horn are made by joining two or more plates together by heating them sufficiently to melt, but not to decompose, the horn, and subjecting them to pressure ; when well done the juncture cannot be perceived.

If a work in horn, as a large comb, is required to be of a curved or wavy figure, it is finished flat, and is then put into boiling water until it becomes soft, when it is transferred to a die of hard wood, in which it is pressed, and there remains until cold.

Horn is colored by boiling it in infusions of colors. Imitations of tortoise-shell are made by applying hot a solution of pearlash, quicklime, litharge, and dragon's blood. This is laid on in streaks and blotches to imitate the shell, and a second application gives the darker spots. Horn drinking-cups are made by cutting the horn into lengths, softening, expanding the horn on a wooden mold, turning, polishing, bottoming, and mounting. The bottom is cut out by a *crown* saw, and is pushed into a groove near the bottom of the cup, the softened horn allowing it to pass, and contracting to hold it safely.

Horn for knife-handles is sawn into blanks, heated, pared, and partially shaped ; then heated in water and pressed between dies. It is afterwards scraped, buffed, and polished.

Deer-horns are worked like bone or ivory.

2. (*Music.*) A wind instrument of metal, of which many elegant and excellent instruments may be considered as varieties. The name (*horn*) suggests the article first used for the purpose : —

Bugle.	Key-bugle.
Clavicor.	Ophicleide.
Cornet.	Post-horn.
Cornopean.	Sarrusophone.
Duplex-pelitti.	Saxhorn.
French-horn.	Saxophone.
Helicon.	Trombone.
Hunting-horn.	Trumpet.
Kent-bugle.	Tuba.

The *French horn* is a brass musical instrument, of a complex, spiral form, increasing in diameter to its end or mouth. The tone is governed by pistons, or by crooks which change the pitch, and the character of the tone by the hand inserted into the mouth or *pavilion*.

The horn of the wild bull, tipped with silver and slung by a silver chain, was the *bugle horn* of the hunter in former times.

The "*echo*" attachment of the horn or bugle is a switch on one of the convolutions of the instrument, by which the sound is conducted through a small pipe, and a diminuendo effect produced, resembling an echo.

The *tuba* is a bass horn, — name from its shape.

Some of these instruments, as those marked *a*, *b*, *c*, *d*, *e*, *f*, *h*, *j*, in the accompanying cut, are made *en suite*, of sizes and compass to take different parts in concerted pieces of music, and are known as, —

Soprano.	Bass.
Contralto.	Double-bass, or
Tenor.	Contra-bass, etc.
Baritone.	

Or by the pitch of the key of the instrument, as : —

E-flat.	B-flat, etc.

The accompanying cut shows several varieties : —

a Sarrusophone.	*g* Clavicor.
b Saxophone.	*h* Trombone.
c Duplex pclitti.	*i* Trumpet.
d d cornets *à pistons.*	*j* Ophicleide.
e Helicon *à pistons.*	*k* Hunting-horn.
f f f Saxhorns.	*l* Post-horn.

3. (*Mechanics.*) A projecting portion of an object.

4. (*Sadd'cry.*) *a.* The high pommel of a Spanish or half-Spanish saddle. Sometimes made of horn.

b. The projections on the forward part of a woman's saddle, between which the right leg is placed. The inside one is the *small-horn*, the outer the *large-horn.*

5. (*Forging.*) The *beak* of an anvil around which objects are bent.

6. (*Nautical.*) *a.* The arm of a cleat or kevel.

b. One member of the jaw of a boom.

7. (*Mining.*) A spoon or scoop of horn, in which washings are tested in prospecting.

8. (*Milling.*) One of the points of a driver, on the summit of a millstone spindle, and which project into the *coffins* of the runner to convey the motion of the spindle thereto.

9. One of the prongs or crutches of an elevating screw or jack.

10. A curved projection on the forepart of a plane.

11. A powder-flask, of horn.

Horn, Ar-ti-fi'cial. *a.* An artificial horn for lanterns was made some 70 years since in France, consisting of brass gauze dipped repeatedly in dissolved isinglass and varnished.

b. Gelatine from bones, tanned by the ordinary process. It is used for the same purposes as horn or tortoise-shell. It is softened by boiling in a solution of potash, when it may be pressed into shape and dried between molds. It may be inlaid while in the soft state, and stained or striped to resemble fancy woods.

c. Caoutchouc, sulphur, gutta-percha, vulcanized by heat; gypsum, resin, or lead may be added, or matter for coloring.

d. Take linseed-oil 10 pounds, protochloride of sulphur 1 pound, bisulphide of carbon 3 pounds. Of the product take 10 pounds; asphaltum, 4 pounds; flowers of sulphur, 2 pounds; crude gutta-percha, 4 pounds. Put in heater and raise temperature to 300° to 350° F.

e. Horn as a substitute for whalebone : —

Boil ox-horns in water, then in oil, press while hot, and cut into shape by circular saws.

f. Towers's patent. Rawhide is dipped in melted sulphur, and molded while in a heated condition. See also PYROXYLINE; IVORY, ARTIFICIAL.

Horn-book. A primer of the fifteenth century. The alphabet, vowels, and Lord's Prayer were printed on a slip of paper, which was covered with a thin layer of horn to keep it from being torn.

Horn-card. A graduated drafting scale or protractor, made of horn.

Horn-drum. (*Hydraulic Engineering.*) A water-raising wheel divided into sections by curved partitions. It resembles one form of TYMPANUM (which see).

Horn-lead. (*Mining.*) Native chloride of lead. So called from its consistence.

Horn-mer'cu-ry. See HORN-QUICKSILVER.

Horn'pipe. (*Music.*) A Welsh wind-instrument, having a wooden pipe with holes at intervals, and a horn at each end.

Horn-plate. (*Railroad Engineering.*) The *axle-guard* or vertical frame in which an axle-box slides up and down as the springs dilate and contract. A *pedestal.*

Horn-quick'sil-ver. (*Mining.*) Native bichloride of mercury or calomel.

Horns. (*Mining.*) The guides for the ropes on the drum.

Horn-sil'ver. (*Mining.*) Native chloride of silver. So called from its conduct under the cutting-tool. Fused chloride of silver.

Horn-tip. (*Husbandry.*) A button or knob placed on the end of the horn of an animal of the cow kind. It is usually put on to render the horn less dangerous, sometimes for ornament.

Horn-work. (*Fortification.*) A work consisting of two *half-bastions* and a *curtain*, with two long sides called *wings*, which connect it with the main work, by which it is commanded.

Fig 2565.

Horn-Work.

It is an extended defensible position to occupy advantageous ground or to command ground otherwise unseen.

Hor'o-loge. A timepiece; a clock or watch. See next article.

Hor'o-log'ic-al In'stru-ments. Time-measurers. See —

Alarm-clock.	Electric clock.
Alarm-watch.	Electric pendulum.
Astronomical clock.	Electric time-ball.
Balance.	Electro-magnetic clock.
Barrel.	Equation-watch.
Calendar-clock.	Escapement.
Cannon-clock.	Fusee.
Case-winding watch.	Flying-pinion.
Center-seconds watch.	Globe-clock.
Chime-barrel.	Gnomon.
Chronograph.	Going-barrel.
Chronometer.	Going-wheel.
Clepsydra.	Gridiron-pendulum.
Clock.	Hair-spring.
Clock-movement.	Half-minute glass.
Clock-pillar.	Hammer.
Compensation-balance.	Hammer-tail spring.
Compensation-pendulum.	Hand.
Count-wheel.	Hawk's bill.
Cuckoo-clock.	Heliotrope.
Curb-pins.	Hour-glass.
Dial.	Hunter-watch.
Dial-work.	Hydraulic clock.
Ding-dong.	Hydroscope.

Illuminating-clock.
Independent seconds' watch.
Jewel. Watch
Lepine-watch.
Lid-winding watch.
Lifting-piece.
Log-glass.
Mainspring.
Micronometer.
Minute-glass.
Minute-hand.
Minute-jack.
Motion.
Movement.
Musical clock.
Panto-chronometer.
Pendant.
Pendant-winding watch.
Pendulum.
Polar-clock.
Polar-dial.
Potence.
Prill-piece.
Rack.
Rack-hook.
Rack-tail.
Regulator.
Repeating-watch.
Rolling-pendulum.
Sand-glass.
Sidereal clock.
Snail.
Solar-chronometer.
Star-wheel.
Stem-winding watch.
Stop-watch.
Stop-work.
Strike or silent.
Sun-dial.
Telegraph-clock.
Time-ball.
Time-piece.
Train.
Turret-clock.
Verge.
Warning-piece.
Watch.
Watch-alarm.
Watch-case.
Watch-clock.
Watchmaker's files.
Watch-regulator.
Watch-screw.
Watch-spring.
Water-clock.

Ho-rom'e-ter. An instrument for measuring time, as a *clepsydra*, *clock*, *dial*, *watch*. See previous article.

Hor'o-scope. A species of planisphere invented by Jean Paduanus. See PLANISPHERE.

Horse. 1. (*Nautical.*) *a*. A foot-rope attached by *stirrups* beneath a yard for the seamen to stand on in reefing. A *foot-rope*.

b. A breast-rope in the chains to secure the leadsman.

c. An iron bar across a boat for a stay-sail sheet or boom-sheet to travel on.

d. A rope reaching from the *knight-head* to the upper part of the *bowsprit-cap*, for the safety of the men walking out upon the bowsprit in rough weather.

2. A wooden bar or frame with legs, used for supporting something. As a *clothes-horse* for clothes; a *saw-horse* for a board or timber while being sawed; a frame to hold a saddle; a *trestle* for joiner-work to rest upon while being keyed up.

A *shaving-horse* is a beam supported by legs, and having a *jaw* which is closed by the pressure of the feet against the treadle below, and is thereby caused to hold a shingle, axe-handle, spoke, or other article while being shaved by a *drawing-knife*.

3. (*Leather.*) The trestle or sloping board of the currier on which he spreads his skins while currying.

4. (*Printing.*) A slanting board at the end of the *bank* or table, to hold a supply of paper for a press.

5. (*Mining.*) A mass of earthy matter intervening between the branches of a vein of ore or coal. The vein straddling on each side of the non-metalliferous rock is said to *take horse*.

6. (*Hydraulic Engineering.*) That on which the mooring of a flying-bridge rides and traverses, and which consists of two masts with horizontal beams at their heads.

7. A hook-shaped tool used for hammered or raised work.

8. A vaulting-block in a gymnasium.

Horse-ar-til'ler-y. Flying artillery. Gunners mounted on horseback and on the limber.

Horse-boat. A ferry-boat moved by horses. The horse-power may be applied to paddles or to a rope stretching across the stream.

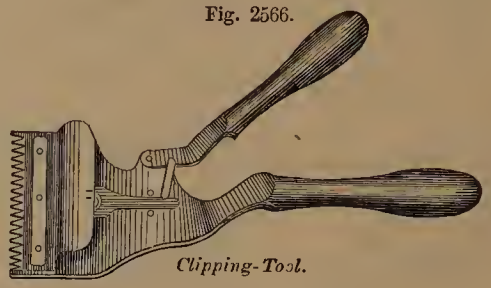
Horse-box. (*Railway.*) The English term for a horse-car used in shipping gentlemen's horses between town and country as the seasons come and go; sending hunters on to the *meet* that they may be fresh for a start; forwarding animals to exhibitions, to market, etc.

Horse-brush. (*Menage.*) One for grooming horses. Such are usually elliptical in shape, but have been made long and flexible with a handle at each end to lap around the legs.

Horse-cap'stan. A *whim*. A capstan worked by horses for raising ore, water, etc.

Horse-clip'ping Tool. A form of shears in which a pair of serrated knives reciprocate over each

Fig. 2566.



Clipping-Tool.

other, cutting off the hairs, which are cut as they come between the teeth.

Horse-col'lar. A roll of leather stuffed with straw, husk, or sponge, and placed around the neck of a horse and against the shoulder, to pull by. It has two creases to hold the hame. See COLLAR, 4.

Horse Ferry-boat. One in which paddles or a rope reaching across the river are worked by a horse on board the boat.

Horse-gear. The English term for the horse-power, applied to thrashing-machines, pumps, etc. See HORSE-POWER.

Horse-hair. The hair of the manes and tails of horses, used in making haircloth, etc. See HAIR-CLOTH.

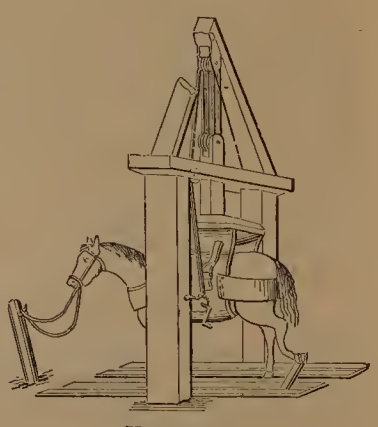
Horse Hay-fork. See FORK; HAY-FORK.

Horse-hoe. The English name for the cultivator for crops in rows. See HOEING-MACHINE.

Horse-hitch'ing Hook. (*Menage.*) A snap-hook on a short chain or strap attacked to a post or wall. The hook is snapped into the bit-ring, and the arrangement saves the trouble of carrying a hitch-strap.

Horse-hold'er. (*Menage.*) A stocks or slinging frame for unruly horses while shoeing, or for sick or disabled horses.

Fig. 2567.



Horse-Holder.

In the example, the horse is raised by a wide belly-band that is connected to and operated by pulleys above. The foot to be shod is secured to a sliding post that runs in a groove on the floor.

Horse-i'ron. (*Shipwrighting.*) A calking-iron of large size. A *making-iron*.

Horse-lit'ter. (*Vehicle.*) A palanquin or stretcher resting on poles and borne by two horses.

Horse-mill. A mill turned by a horse. See GRINDING-MILL; MILL.

Horse-nail. A nail with a thick, strong head; used in securing shoes to the feet of horses. See HORSE-SHOE NAILS.

Horse-path. (*Hydraulic Engineering.*) The *towing-path* of a canal.

Horse-power. 1. The measure of a steam-engine's power, as originally settled by James Watt. A lifting power equal to 33,000 pounds raised one foot high per minute. This was taken by Mr. Watt as the average power exerted by a mill-horse traveling at the rate of 2½ miles an hour (or 220 feet a minute), and raising a weight of 150 pounds by a rope passing over a pulley.

When a steam-engine is declared to be of such or such a horse-power, the expression must be understood in a qualified sense. Thus it is assumed that the furnace is worked in a certain average manner, and that a proportional evaporation takes place in the boiler. An engine whose nominal power is that of 100 horses may, by urging the furnace in an extraordinary manner, be made to produce an effect much greater than that of its nominal power; or, on the other hand, by keeping the furnace low, it may be, and frequently is, worked considerably under its nominal power.

For every horse-power which the engine is expected to exert, a power of evaporating one cubic foot of water per hour is provided in the boiler.

For the consumption of the fuel necessary to produce this effect, one square foot of *grate surface* per horse-power is provided.

The boiler requires 15 to 18 square feet of heating surface per horse-power. These are average estimates, the Cornish boiler and the locomotive-boiler being the extremes at each end of the scale.

Many circumstances of arrangement, the perfection with which the fuel is burned, the draft, mode of feeding, character of coal, etc., modify these results.

The power of water-wheels, etc., is expressed in horse-power.

Mr. Tredgold compiled a table showing the maximum quantity of labor that a horse of average strength is capable of performing at different velocities, in drawing *boats* on *canals*, and carriages on railways and turnpike-roads respectively: —

Velocity in Miles per Hour.	Duration in Hours of the Day's Work at preceding Velocity.	Force of Traction in Pounds.	Useful Effect of One Horse working One Day in Tons drawn One Mile.		
			On a Canal.	On a level Railway.	On a level Turnpike.
2½	11½	83⅓	520	115	14
3	8	83⅓	243	92	12
3½	5 9/10	83⅓	153	82	10
4	4½	83⅓	102	72	9
5	2 9/10	83⅓	52	57	7.2
6	2	83⅓	30	48	6
7	1½	83⅓	19	41	5.1
8	1⅛	83⅓	12.8	36	4.5
9	9/10	83⅓	9	32	4
10	¾	83⅓	6.6	28.8	3.6

The average force exerted by a horse at a plow, at a rate of 2½ miles per hour, and with an exertion which he is capable of sustaining for the usual hours per day and every working day, as deduced from dynamometrical experiments at eight plowing-matches, at each of which from 5 to 7 teams were employed, was 163 pounds.

The number of horses subjected to the test was 144, and the observations were made by Mr. Bevan at Woburn and Ashridge, under the observation of some distinguished agriculturists.

In connection with the subject of *horse-power*, it may be well to notice that the terms *power* and *duty* are not synonymous, but opposite, terms.

Power means the quantity of work that can be performed in a given time.

Duty signifies the amount of work that can be performed with a given expenditure of fuel.

To obtain the full amount of *power*, the steam is worked at full pressure the whole of the piston-stroke.

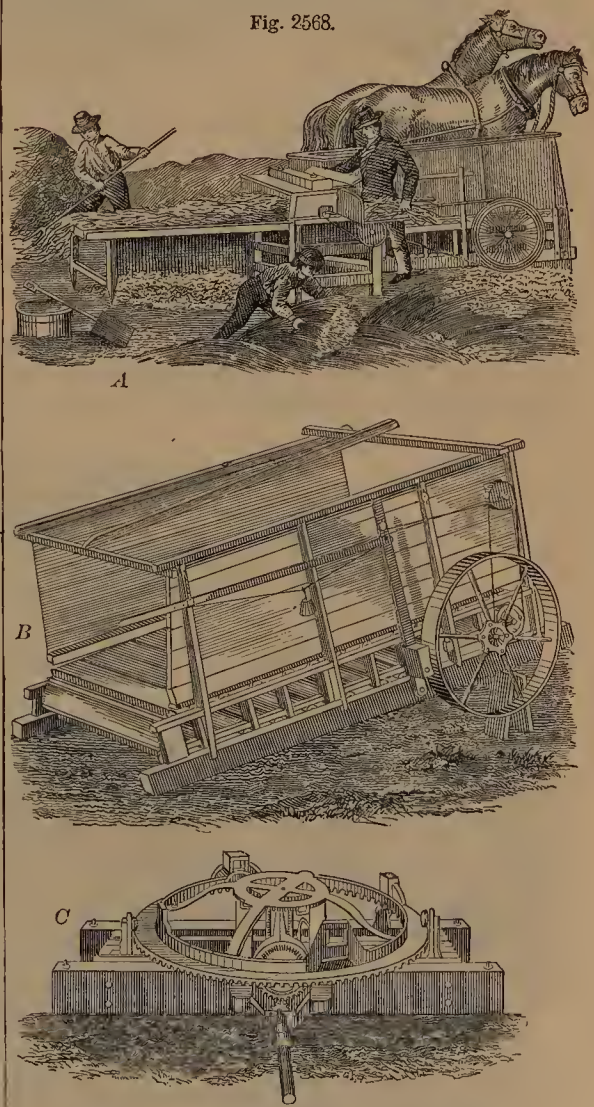
To obtain the highest *duty*, it is used expansively.

A cheap engine, unprovided with the expansion arrangement, will exhibit a greater power than a more expensive engine worked expansively, other things being equal; but the latter will be the more economical in running.

To repeat: power has no reference to the quality of an engine, but to the capacity of its cylinder in connection with a stated pressure of steam. Economy or waste of steam in working does not enter into the question.

Duty disregards time, and the size or power of the engine. It merely inquires how much work is done by a given expenditure of fuel. See CUT-OFF; DUTY.

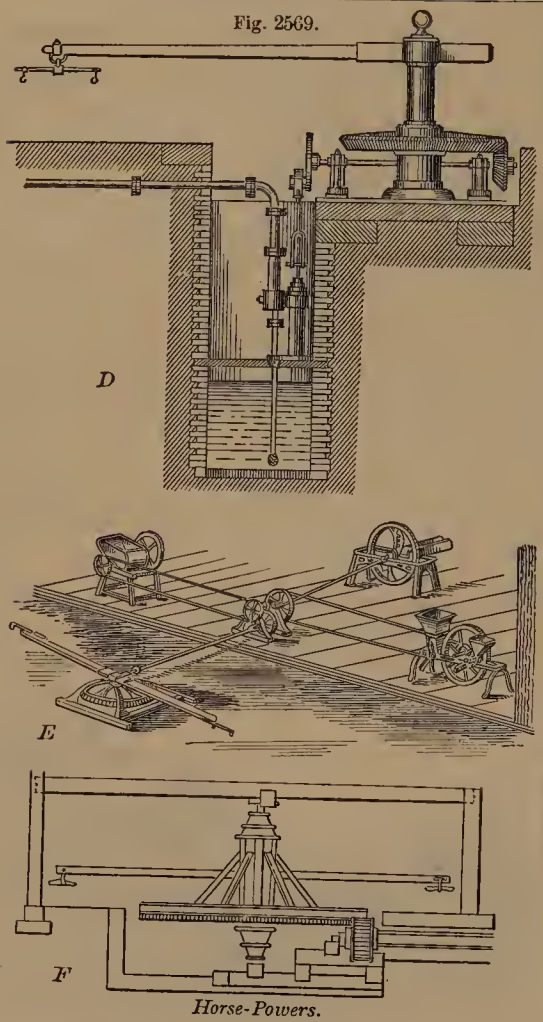
Fig. 2568.



Horse-Powers.

2. A machine in which the power of horses is exerted to drive other machinery.

Fig. 2569.



Horse-Powers.

A (Fig. 2568) is one which the horses walk upon a traveling platform, which slips beneath their feet as the animals pull upon a bar at the rear of the machine. It is shown in connection with a small thrashing-machine.

B is a similar machine without its tenants, and exhibiting the parts more clearly.

C is an ordinary horse-power, such as is used for thrashing-machines, drag-saws, clover-hullers, and corn-shellers. It is dismounted from the wagon, secured by stakes and chains, and levers placed in the sockets, which in this case are four in number, intended for two horses to each lever.

The diameter of the path should be 25 to 30 feet. The horse works to best advantage at 2½ miles per hour of 220 feet in a minute. The force is estimated at 22,000 pounds raised one foot high per minute, which is 66 per cent of the power exerted in drawing in a direct line.

D (Fig. 2569) is an arrangement of horse-power for working a pump.

E is an arrangement for driving a cutting-box, grinding-mill, and corn-sheller, for either of which a hominy-mill or apple-grinder may be substituted when desired.

F is an English arrangement, in which the crown-wheel drives a lantern pinion.

Fig. 2570 shows the English horse-power as applied to a straw-stacker, placed at the delivery end of the straw-carrier of a thrashing-machine. It has a master-wheel and pinions, and the power is conveyed by belting and shafting to an endless apron with tines.

Fig. 2571 shows an American mounted horse-power, that is, one which is used without dismounting from the wheels, by which it is moved from place to place. Power can be applied from both sides and both ends at the same time, or from either point alone, as desired. *U* are the levers to which the horses are attached; *C* is the master-wheel, driving the pinions on shaft *F*, which carries the wheels *D G*; the latter convey motion to the pinions on the inner ends of the tumbling shafts.

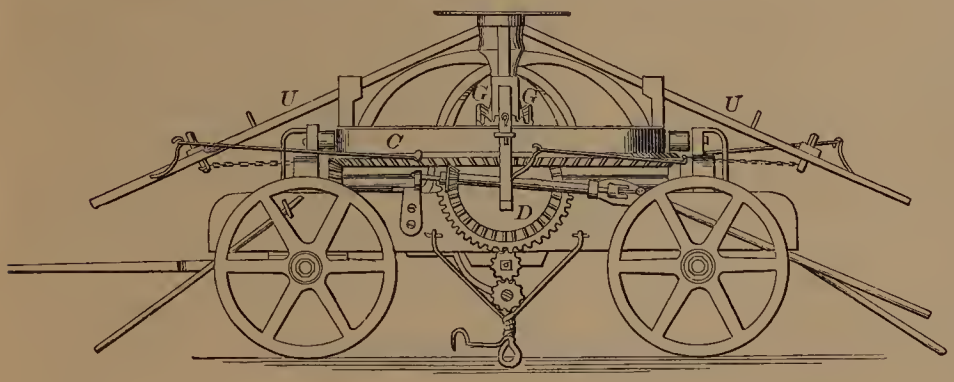
Horse-rail'road. A railroad for city or suburban use, whose cars are drawn by horses.

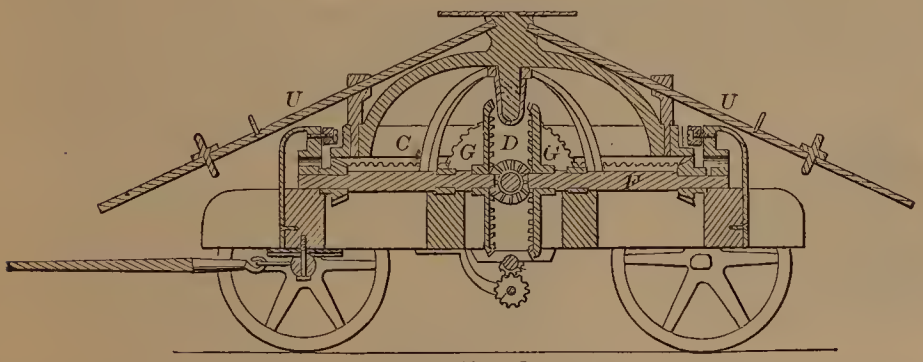
The first railroads were in mines, and for carrying

Fig. 2570.

English Horse-Power.

Fig. 2571.





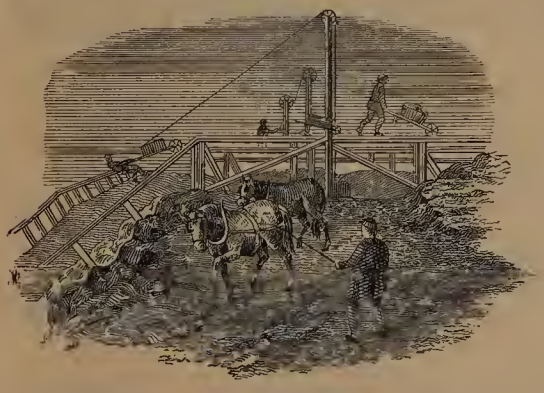
Mounted Horse-Power.

coal to the seaboard. These are yet, many of them, worked by horse-power. See RAILWAY; STREET-RAILWAY; LOCOMOTIVE.

Horse-rake. A hay or stubble rake drawn by horse-power. See RAKE; HAY-RAKE.

Horse-run. A device for drawing loaded wheelbarrows up an inclined plane in making excavations.

Fig. 2572.



Horse-Run.

It consists of a rope passing over two pulleys. The horse is hitched to the fall and the wheelbarrow hooked to the other end of the rope.

Horse'shoe. 1. (*Menage.*) Horses were not shod in Egypt, Assyria, or Palestine. The latter country was supplied with horses by the Egyptians. Solomon paid 150 shekels of silver, equal in value to $75, for each horse. This was a high price, the difference in relative value of the shekel and a given weight of wheat, meat, or other necessary, being considered.

Isaiah speaks of horses whose "hoofs shall be counted like flint," — a valuable quality where they were shoeless.

The Syrians and Hittites were supplied with Egyptian horses by Solomon, who turned an honest penny by this means.

Aristotle and Pliny mention the covering of horse's feet in stony places to protect the hoof from breakage and wear, but it is probable that such

Fig 2573.

Japanese Horseshoe.

covering was a bandage or boot, and was used principally on long journeys. Suetonius refers to the dismounting of Vespasian's muleteer to shoe his mules. Wrappings of plaited fiber, such as hemp or spartium (broom), were used, as was also leather.

In Japan the horses have clogs of twisted straw, of which a large supply is carried on a journey. When worn, another is immediately applied. Our plan would no doubt appear a barbarous custom in their minds. The Siberians and Kamtschatkians use traveling-socks for their dogs. Captain Cook refers to them.

Camels in old times were similarly provided, as we learn from Aristotle and Pliny. These boots were drawn on over the feet, and it does not appear that iron or other metallic plates were nailed to the hoofs. Such boots were shod with metal for the rich. The mules of Nero were shod with silver; those of his wife Poppæa with gold. Xenophon, Arrian, Artemidorus, refer to these boots. For less stately purposes mules were shod with iron.

> "Ferream ut soleam tenaci in vargine mula."
> CATULLUS.

Homer mentions brazen-footed steeds (Iliad, VIII. 41, and XIII. 24), probably a merely metaphorical expression implying strength. Mithridates and Alexander experienced great difficulty with their cavalry, owing to the soreness of the unprotected feet of the horses in long marches. Pollux, in his dictionary, does not mention horseshoes of metal. The first certain mention of shoes nailed to the hoofs is in the works of the Emperor Leo, ninth century. The practice of shoeing horses is said to have been introduced into England by William I.

The principal parts of a horseshoe are: the two *faces*, upper and lower; the two *edges*, inner and outer; the toe, or front part; the *quarters*, between the toe and the heels; the *calks*, projections from the lower part of each heel; steel calks are also frequently added to the toe; the *fullering*, or crease in the lower face, in which the nail-holes, generally

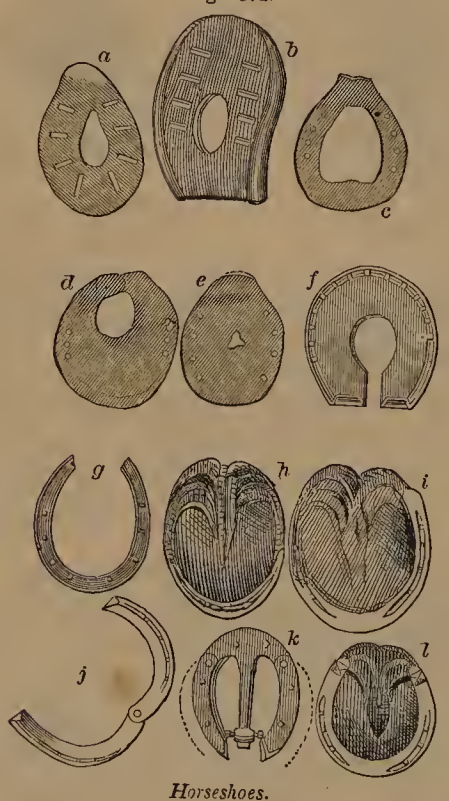
eight, are made ; the *clip*, a kind of claw, usually at the upper edge of the toe, for protecting the hoof and assisting to keep the shoe in place.

The upper face is beveled, or made slightly concave, to prevent the iron from resting on the arch of the sole of the foot.

Horseshoes made by machinery are now generally employed. They are made of five sizes, and are numbered from 1 to 5, the first being the smallest and the latter the largest. Nos. 3 and 4 are those most commonly required.

"In two respects," says Loudon, "the shoeing of Holland differs from ours. 1. To prevent splitting, the fore hoofs are pared away at the toe, and the shoe so fitted that the toes do not touch the ground when the foot stands flat ; the weight resting on the middle and the heel of the shoe. 2. The shoe is nailed on perfectly flat and close to the foot, which is flattened to receive it ; the iron is thereby deprived of all spring, and the hold of the nails is un-

Fig. 2574.



Horseshoes.

disturbed." The frog comes in contact with the ground. This mode of shoeing may not commend itself to our farmers and teamsters, but the Dutch have good horses, use them well, work them hard, and their practice is worth considering.

A *bar-shoe* is one in which the shoe is continued round below the heel. It is used on hoofs liable to contraction at the heel, its purpose being to keep them spread.

A *stifle-shoe* is one with a round bar, convex side downward, giving it an unsteady foundation on the ground. It is placed on the foot of the *well* hind leg, so as to compel or induce the animal to throw the weight of the hind quarters on the other foot to reduce the luxation or weakness at the stifle-joint of the leg.

In 1810, Rotch obtained an English patent for an elastic horseshoe, consisting of a sheet-iron sole attached to an india-rubber upper, which was slipped upon the foot, clasping the crown and encircling the pastern. A regular shoe was riveted to the sheet-iron sole of the boot when required. The *upper* or caoutchouc band was prolonged upward as far as deemed necessary, and, in case of *interfering* horses, was made to cover the fetlock. He also applied the caoutchouc bands to the knees, as *knee-caps*.

Charlier substitutes for the ordinary shoe an iron band, let into a rectangular groove scooped from the outer circle of the horse's foot. This band is fastened with seven rectangular nails, driven into oval holes. The soles of the foot and the frog are thus allowed to touch the ground.

Dudley's *cast-iron* horseshoe, English patent, 1823, was cast in a mold modeled from the foot of the horse, and subsequently rendered malleable in a furnace.

Besides the construction of the shoe proper, there are certain attachments thereto, such as, —

Snow-pads, which fit within the shoe and prevent the accretion of snow or ice therein.

Movable calks, which may be attached at any time, if the ground freeze or become sleety during a journey.

a represents an early Arabian shoe.
b, an Arabian shoe of modern date.
c, a Moorish shoe.
d, a Persian shoe.
e, a Portuguese shoe.
f, an old English shoe.
g, a racing-plate.
h, a tip-shoe.
i, a three-quarter shoe.
j, a jointed shoe.
k, a screw-shoe.
l, a calked shoe.

Fig. 2575 illustrates various horseshoes.

1. The bifurcated springs *a a* clip the hoof, and are attached to the shoe by bolt and nut.

2. Countersunk-headed screws parallel to the wall of the hoof are employed for fastening the shoe.

Fig. 2575.

Horseshoes.

3. Ridges and indentations are formed upon the sole of the shoe. Goodenough's horseshoe has an indented ridge on its under side, perforated for the insertion of nails.

4. For contracted hoofs. By means of the screw

a and nuts between the heel-clips the branches of the shoe may be spread and maintained the proper distance apart.

5. A supplemental roughing shoe is attached to the upper shoe by clips *a a* and a sliding screw-block *b*. Pins at the rear prevent lateral displacement.

6. The shoe is hinged at the toe, and is designed to be permanent. It is beveled on its upper inner edge, to receive the flange of a removable false shoe, that is expanded outwardly by a screw, so as to fit snugly to the permanent shoe, and sustain all the wear.

7. A double-shoe. The upper one is hinged at the toe, and has a jointed cross-bar at the heel; curved clips *a a b b* fit the walls of the hoof and secure the shoe in place. To this the lower plate *c* is secured by screws.

8. The shoe is attached to the hoof by pieces of leather at the front and quarters secured by connecting straps.

9. The shoe has a toe-cap, is jointed at the sides, and has clips and pivoted catch or connecting bar at the rear, dispensing with nails.

10. Rear clips *a*, toe-cap *b*, and strap *c*, held by a button on the toe-cap, hold the shoe to the hoof.

11. The removable toe and heel calks *a b* are dovetailed into plates *c d*, which are fastened to the shoe by screws.

12. The toe and heel calks are adjustably fastened to the shoe by screws.

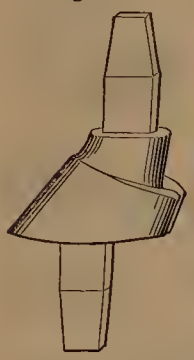
See Fleming's "Practical Horseshoer"; "Rational Horseshoeing," N. Y., 1873.

Refractory animals are confined in a *brake* while shoeing. The brake for cattle is represented under Ox-shoes (which see). The brake for horses consists essentially of an arrangement of straps to bear the weight of the animal, and to prevent his lunging forward, backward, or rearing; also of posts or bars to which his hind or fore feet are lashed while shoeing.

2. (*Lathe.*) A movable support for varying the gearing and the velocity of the screw which moves the slide.

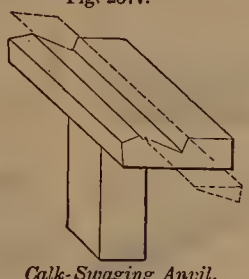
Horse'shoe-an'vil. One which corresponds in shape and size to the hoof of a horse, and has shanks

Fig. 2576.



Wilkinson's Anvil.

Fig. 2577.



Calk-Swaging Anvil.

which permit its adjustment in the socket-hole of the anvil, in either a natural or a reversed position. It affords a means of making and fitting the bands and clasps by which the removable horseshoes are attached, in place of nails.

The calk-swaging anvil has a groove across its face, in which a bar of metal is swaged to the level of the plane surface of the anvil, thereby acquiring a triangular shape in cross-section, and forming a rod from which sharpened calks may be cut.

See Anvil, pp. 121, 122.

Horse'shoe-clamp. (*Shipbuilding.*) An iron strap by which the *gripe* and *fore-foot* are attached. See Stem.

Horse'shoe-ma-chine'. A machine in which bar-iron is converted into horseshoe blanks or horseshoes.

Burden of Troy, New York, patented a machine for this purpose in November, 1835, which had segmental reciprocating dies to shape a straight blank by giving it the requisite thicknesses at the respective parts, and the creases for the nail-heads. The piece rested on a rocking anvil-bed. His patent of September 10, 1843, described a reciprocating rectilinear movement, cutting off from a heated rod a straight blank and impressing by dies, which made the fullering and nail-holes. His patent of June 20, 1857, was reissued June 3, 1865, and extended in 1871. In it the motions are rotary and continuous. The red-hot bar is introduced at the side of the machine, and a sufficient piece cut off by a descending cutter. It passes between guides to a stop, and is held in place till a bending-piece on a roller comes against it and carries it along. This piece corresponds to the inner shape of the shoe, and with this as a former the blank is carried past a series of dies which press it to shape, thinning the inner edge, thickening the heels, pinching in the heels, making the creases by dies and the nail-holes by punches, in succession. After flattening, the shoe is dropped from the machine.

Other forms of machines have circular beds, carrying formers which pass the blank between dies which act successively upon the edges and face to give the required proportions and contour, as well as the creases and nail-holes.

Another form pinches the heated blank between a center former and two posts, while top rollers shape it vertically and side rollers lap the heels around the receding portion of the former, which acts as a die.

In another, the bar is fed in between the shears until it butts against the adjustable gage-plate. Being severed by the shears, the bender advances and drives it between a pair of rollers, giving it a proximate horseshoe shape. The heels of the shoe fall into a depression, and as the bender retires the shoe is drawn from it. The creasing and nail punch are on an oscillating lever, and the latter acts upon and in conjunction with a lower lever, which perfects the perforation.

In one rotary form of machine, the *former* which carries the blank is rotated first between two friction rollers placed on and under a stationary bridge, then under a reducing-roll, a guide-roll, finishing bending device, and hammering-rolls, the shoe being discharged by a pin thrown up by a cam.

Horse'shoe-mag'net. An artificial iron magnet of a horseshoe form.

Horse'shoe-nail. A nail made of superior soft iron and used to fasten on horseshoes. It has a flat pointed tang, and a relatively heavy countersunk head. See Nail.

Lengths of horseshoe nails: —

No. 5.	$1\frac{1}{2}$ inches.	No. 8.	2 inches.
No. 6	$1\frac{3}{4}$ "	No. 9	$2\frac{1}{4}$ "
No. 7.	$1\frac{7}{8}$ "	No. 10.	$2\frac{1}{2}$ "

Horse'shoe Nail-ma-chine'. One in which rods of iron are shaped into nails for the purpose stated.

In one form of this machine, the nail-rod is fed downward through a heating furnace in front of a stationary anvil by means of a cam geared to make one movement. As each finished nail is cut off at right angles to the face of this anvil, two sliding hammers, having faces of the contour the reverse of the sides of the finished nail, are forced against the sides of the blank simultaneously by means of

springs; a third hammer works perpendicularly to the face of the anvil, alternately with the other two, by which the nail is forged. When the nail has been sufficiently hammered, it is cut off by a knife moved against it at the top of the anvil by a cam.

In another, the nails are made directly from the rod by a continuous operation, the blank from which the nail is to be made being first cut from the rod and then passed successively through a series of revolving dies operating in pairs, by which it is gradually drawn down and finished.

Horse'shoe-rack. (*Nautical.*) A sweep curving from the bitt-heads abaft the mainmast carrying a set of nine-pin swivel-blocks, as the *fair-leaders* of the light running-gear, halliards, etc.

Horse-tail. 1. Dutch rush, used for scouring.

2. A Turkish standard, the number indicating the rank of a commander.

Hors'ing-block. A frame to raise the ends of wheeling-planks in excavating.

Hors'ing-i'ron. (*Nautical.*) A calker's chisel attached to a withy handle, and used with a beetle in driving oakum into a vessel's seams.

Hors'ing-up. (*Shipwrighting.*) The final driving of oakum into the seams between the planking of ships. See MAKING-IRON.

Hose. 1. Flexible tubing, usually for the conveyance of water, especially for fire-engine service. Smaller hose is used for street-watering, for gas service with drop-lights, for acoustic instruments, stems of bubble-bubbles, hookahs, etc.

Various are the materials: —

Fabric covered with leather.

Wire, cement, and intestine.

Paper saturated with paraffine.

Fabric saturated with carbolic acid and copper salts.

Woven tubes of fibrous material saturated with caoutchouc; or treated with corrosive sublimate, chloride of lime, pyrolignite of iron, resinous materials.

Fabric coated or lined with caoutchouc or gutta-percha in solution.

Leathern hose, treated with beeswax, linseed-oil, and pitch.

Rings or spiral twist of hard-rubber, in or outside of hose, and vulcanized all together.

Internal and external rubber tubes; intervening concentric, seamless tube, woven or braided; all vulcanized together.

India-rubber or gutta-percha tube, around which is woven or braided a netting of cord, yarn, or wire.

Hose is made by longitudinal extension through dies, or of a seamless fabric by knitting or braiding, by winding in spiral slips, or by lapping around a mandrel as long as the sections, which are afterwards coated. Different materials require various treatment.

Another mode of making hose is by feeding a tube of fabric, leather, or other material, through systems of revolving bobbins, which braid upon the tube a cord or twine covering. See Fig. 2584.

Fig. 2578 shows a number of kinds of hose, the differences being in the modes of winding, joining, material, character, and succession of the folds, etc.

a is a flexible hose of woven and lapped tubes and water-proof linings.

b is a similar hose with the waterproof material as a coating.

c is a flexible pipe made of woven fabric with a water-proof lining, and riveted.

d, a tube of rubber or gutta-percha, or of fabric coated with the gums, closely wound with twine.

e, a hose made of two or more concentric seamless tubes of fiber, the inner one lined with caoutchouc.

f has a cemented strip over the seam.

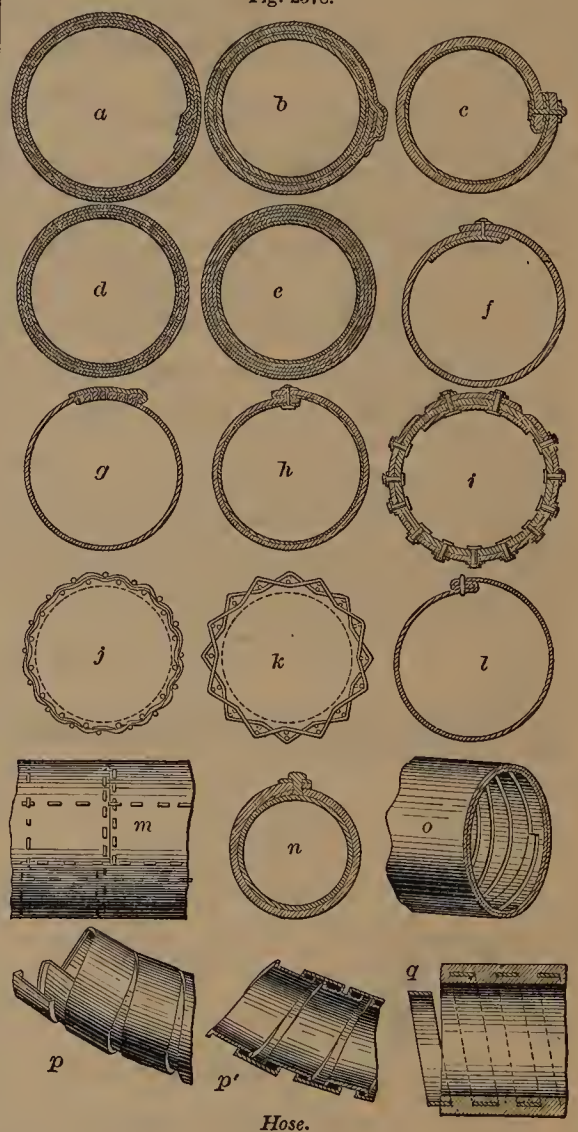
g is stitched through and through with several rows, and the sections joined with diagonal rows of stitches. A welt covers the outside of the join.

h has a fibrous covering, rubber lining, and riveted junction.

i has a double row of rivets along the seam, and a spiral doubly riveted welt lapping the oblique junction of sections.

j is made of strands of fibrous material soaked in

Fig. 2578.



Hose.

gutta-percha or rubber cement, and then woven or braided.

k, an outer tube of wire or twine, is woven or braided upon an inner tube or lining.

l, hydraulic hose whose meeting edges are interlocked so as to present a fourfold thickness to the rivets.

m has a lapped seam sewed with leathern thongs.

n is leathern hose with a spiral metallic lining.

o is a suction-hose having a spirally laid flat wire lining and a seamless textile fabric covering treated with waterproof material.

p p' are two views of a suction-hose showing a stiffener made of two spiral bands which engage

each other by means of inward and outward flanges.

q is a vuleanized rubber suction-hose composed of an exterior body, an interior lining, and an intermediate spirally coiled metallie strengthening rib.

Flax or hempen hose woven without a seam, and payed with waterproof material, was used generally on the continent of Europe previous to the introduction of india-rubber hose.

Leather was used in England and in the United States, and still maintains its ground for some purposes. Leathern hose was first sewn with waxed twine, then copper wire was substituted, and finally riveting.

Leathern hose, made in detachable sections, for application to fire-engines, was invented by Heide, a Dutchman, in 1672, and was common in the Netherlands soon after.

The spiral eoil of wire inserted throughout the length of suction-hose, to keep it from collapsing, was used with the Newsham fire-engine, London, about 1780.

Rubber hose is made by wrapping RUBBER-CLOTH (which see) around a tube of the required size, the number of plies depending upon the required strength. The tube is then placed in a heater and subjected, for a sufficient time, to a steam pressure of 80 pounds to the square ineh = 280° F., which melts the sulphur and vulcanizes the gum.

The tube is then withdrawn from the hose.

Or a sheet of rubber wrapped on a tube and covered by several webs of cloth, saturated with prepared rubber, and eventually by a sheet of rubber. The hose, when formed, is taken to a steam-boiler of great length, where, while still remaining upon the iron pipes, it is heated and cured by a proeess similar to that before described ; after whieh the rubber is drawn off from the pipe, and it is ready for the market.

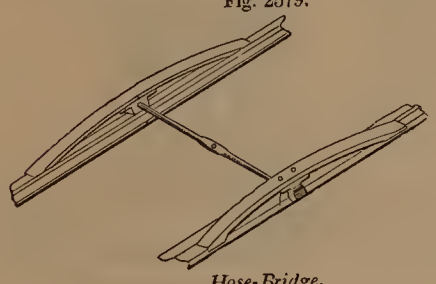
Among the earliest mention of hose is the following passage in Herodotus (450 B. C.). It refers to the mode of watering the hosts of Cambyses the Persian, during his passage of the desert to attaek Psammenitus, the son of Amasis, the Pharaoh of Egypt : —

"There is a great river in Arabia, ealled the Corys, which empties itself into the Erythræan [Red] Sea. The Arabian king, they say, made a pipe of the skins of oxen and other beasts, reaehing from this river all the way to the desert, and so brought the water to certain eisterns which he had had dug in the desert to receive it. It is a 12 days' journey from the river to this desert traet. And the water, they say, was brought through 3 separate pipes, to as many different plaees." — Book III. c. 9.

He adds that it is an improbable story, but that he will not pass it by altogether. The *idea* certainly, so far as we are concerned, is as old as the recorder, who wrote about 2300 years ago.

2. (*Printing-press.*) A case connected by hooks with the platen, for guiding and raising it.

Fig. 2579.



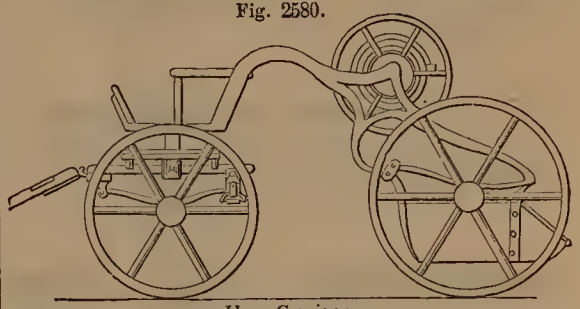
Hose-Bridge.

Hose-bridge. A bridge for earriages or street-ears to allow them to cross fire-engine hose laid in the street.

One form of it was patented by Demarest in 1853. The example shown is to bridge hose which lies across a street-railway.

Hose-car'riage. A reel on wheels to carry hose for fire-engine service. In the example, a fuel-box

Fig. 2580.

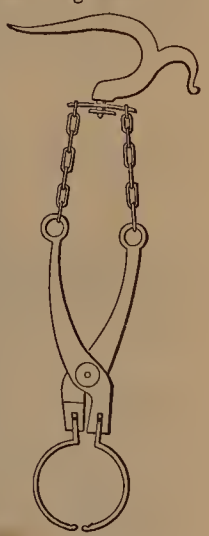


Hose-Carriage.

for the boiler-supply is supported on the same frame. The front wheels turn beneath the elevated pereh.

Hose-car'ri-er. A tongs for gripping hose in *lighting up* full hose when in service.

Fig. 2581.



Hose-Carrier.

Hose-coup'ling. A joint-piece or pair of interloeking connecting pieces, by which ends of hose-sections are joined together in line. There are many forms.

a has a swivel whieh fits against a collar on the nipple, and its flanges are engaged by the sleeve, whieh also screws upon the back screw on the other nipple, pressing the ends of the seetions against the intervening annular packing.

In *b*, the segmental rib and projected screw-bloek of the outer coupling-piece enter a eireumferential groove of the other piece.

In another ordinary form, the sections of hose are bound with wire, or thimbles upon collar-pieces, one of whieh has a threaded exterior and the other a threaded sleeve, whieh screws upon the former. A *spanner* or wrench is used to tighten the connection.

In *c*, a portion of the threads on the screw and socket are eut away to enable the parts to be slipped past each other, and lock by a partial revolution, when the undivided threads catch and complete the joint.

d. The two parts are slid together and the pins enter their respeetive grooves at the opposite sides ; the handle is then turned, and the cam-head locks the parts together.

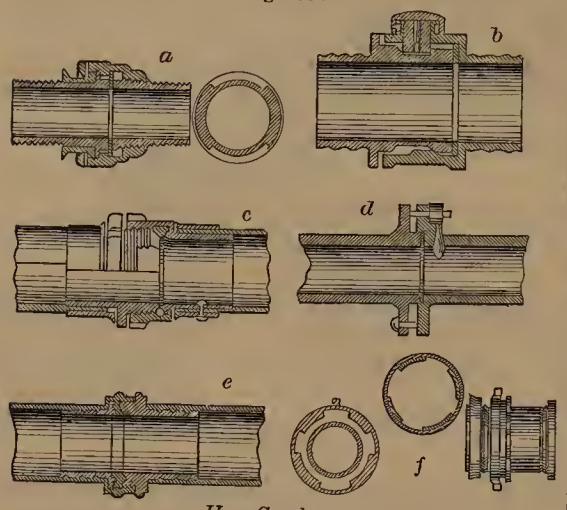
e. The packing-ring is formed to enter two rectangular annular grooves in one part of the coupling and a V-shaped annular groove in the other part.

f. The projections on the outer cylinder interlock with a groove in a collar on the inner cylinder. Expansible packing is enclosed between collars and is forced against the outer cylinder by compression. The hose is brought over the eonvex, eireumferentially grooved ends of the eoupling and confined by a screw-threaded ring.

In the Westinghouse coupling for air-brake pipes of railway-cars, the parts are eonneeted by a spring-

hook fastening. Each half-coupling contains a puppet-valve which seats outwardly. Guiding wings

Fig. 2582.



Hose-Couplings.

are made on the valve-stems, and the stems project outwardly such distance that when the hose are coupled up, the stems, coming end to end, will each unseat the other valve. Hence, when the couplings are united, the valves will always be open, and *vice versa*. See BRAKE.

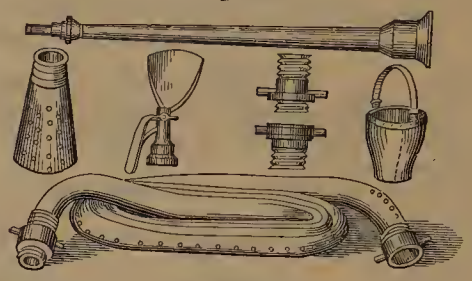
Hose-fit'tings. The various parts by which hose are attached section to section, or a section of the hose to the engine or the nozzle.

The nozzles are of various kinds. The cut shows,—

A *branch-pipe*, with *jet* or *nozzle*.

A *strainer* for the end of the supply or *suction hose*, which is let down into a cistern.

Fig. 2583.



Hose-Fittings.

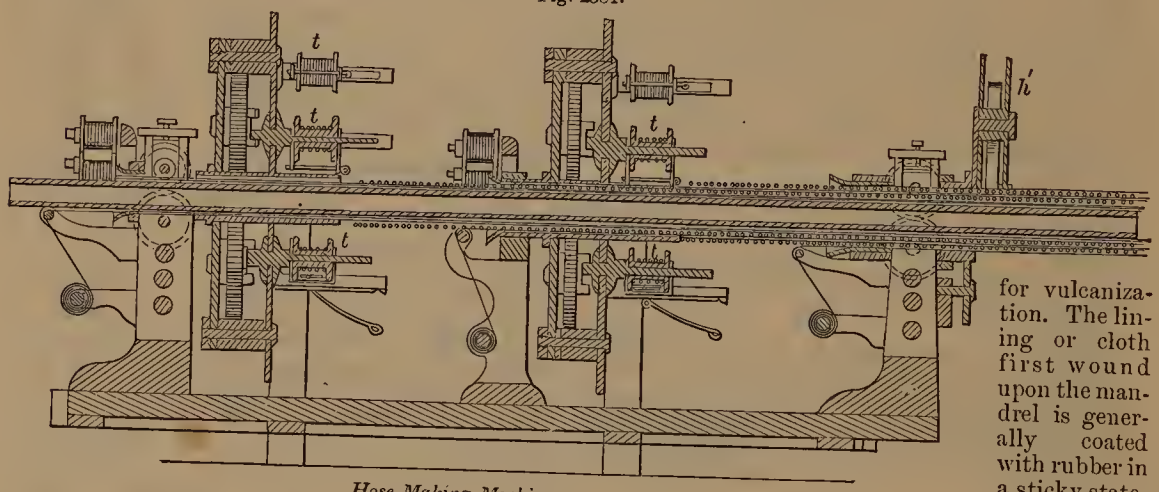
A *sprcader* jet.

Couplings or *hosc-unions*.

A leathern fire-bucket. These arc also made of canvas or galvanized iron.

A scction of leathern hose, copper riveted, and having coupling sections at each end.

Fig. 2584.



Hose-Making Machine.

Hose-hooks. 1. The hooks by which the platen of a printing-press is suspended.

2. A tongs for carrying hose. See HOSE-CARRIER.

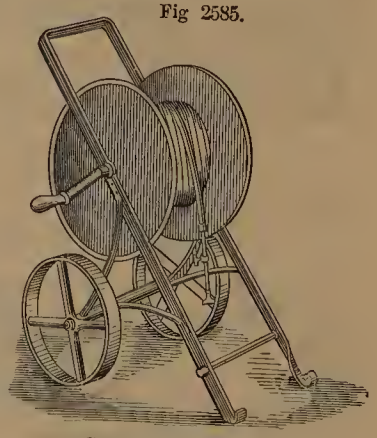
Hose-jump'er. For street railroads. A *hosc-bridge*.

Hose-mak'ing Ma-chine'. A machine for winding or weaving a flexible tube of textile and rubber fabrics.

Fig. 2584 shows a machine adapted to this purpose. A layer of rubber, or cloth saturated with rubber, is wound around a mandrel which extends the full length of the machine. As the fabric moves along from left to right it is wound with thread or wire from the first set of bobbins *t t*. Before it reaches the second set of bobbins for another coating or *ply*, it may receive a set of longitudinal cords, threads, or wires from the intermediate reels. It is then again wound by the second set of bobbins *t t*, and finally receives a coating of cloth, tin-foil, or other material from the spool *h'*, and is then ready for vulcanization. The lining or cloth first wound upon the mandrel is generally coated with rubber in a sticky state, and the longitudinal or transverse binders may be so coated, or saturated with rubber. See INDIA-RUBBER.

Hose-protect'or. A hose-bridge to enable vehicles to cross hose without compressing or cutting it. See HOSE-BRIDGE.

Fig 2585.



Reel for Garden-Hose.

Hose-reel. 1. A carriage to carry hose for the service of a fire-engine. See HOSE-CARRIAGE.

2. A reel to carry hose for garden, stable, or other domestic uses.

Hose-shield. A hose-protector. See HOSE-BRIDGE.

Hose-trough. (*Blasting.*) A wooden tunnel for the powder-hose to fire the charges of mines.

Hos'pi-tal-wag'on. A carriage on four wheels, having four or six springs, used for carrying the wounded of an army. An *ambulance*.

A wagon carrying surgeons' supplies and instruments, or bedding, food, and other supplies for a field hospital. The Prussian hospital-wagons are fitted up with combination cases, in which are packed everything supposed to be necessary in a hospital for wounded, including bandages, splints, drugs and anæsthetics, blankets, and an amputating-table, besides an assortment of tags, on one of which the surgeon writes his orders as to what is to be done in each case, attaches it to the patient, and leaves him to the care of others. Five ambulances, three supply-wagons (carrying food, bedding, and tents), and two surgeons' wagons constitute a hospital train for a division, and will accommodate 200 patients, requiring 13 surgeons and 74 men for their care.

Hot-air En'gine. One driven by the heating of a body of air admitted to the cylinder. They are of two kinds: —

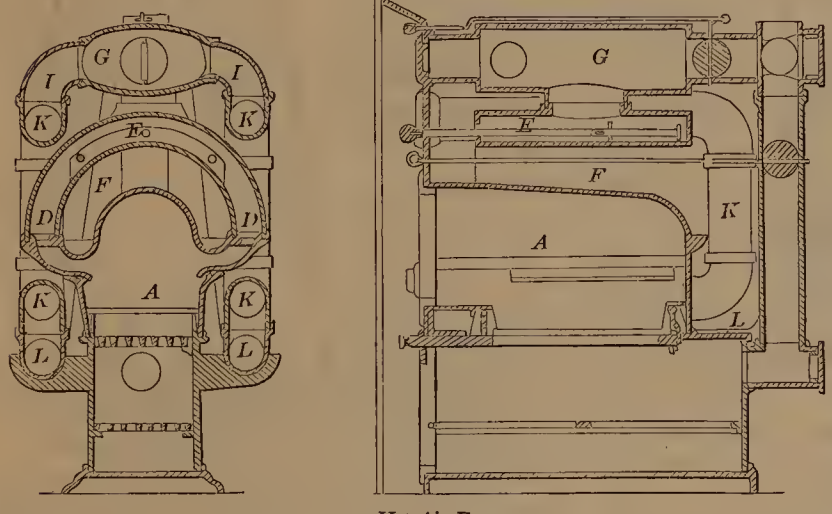
First, those which draw their supplies directly from the atmosphere, and discharge them into the atmosphere again after they have produced their effect. Such are the Ericsson, Stillman, Roper, Baldwin, Messer, Wilcox engines, described on pp. 40 – 43. See also Dr. Barnard's report on the French Exposition, pp. 34 – 40, and plate 1.

Second, those which employ continually the same air, which is alternately heated and cooled, but which is not allowed to escape. Such are the Glazebrook (1797), Parkinson and Crosley (1827), Lauberean (1849), Schwartz, described on pp. 43, 44.

These and other distinguishing features are described under AIR-ENGINE (which see).

Hot-air Fur'nace. One in which air is heated for warming houses, or for purposes of drying, usually the former. The arrangements are various,

Fig. 2586.

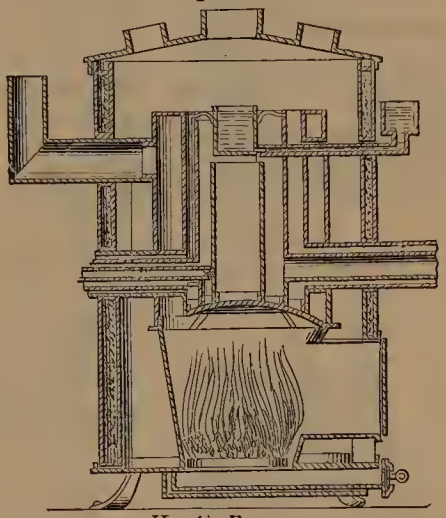


Hot-Air Furnace.

but a common kind is a form of stove in a brick chamber, the air coursing around the stove and among certain pipes and chambers in which circulate the volatile products of combustion. In the example (Fig. 2586) the furnace, with the exception of its face-plate, is inclosed in an air-chamber. The calorie current passes from the furnace *A* around through *D E*, into the auxiliary radiator *G*, down by the V-shaped driving flues *I K L*, and so to the exit. The air circulates around each of the flues in chamber *F*, and against the plates of the furnace.

In Fig. 2587, a series of concentric annular air-flues are placed above the combustion-chamber and communicate with the external atmosphere through

Fig. 2587.



Hot-Air Furnace.

pipes extending into each flue near its bottom. The external jacket of the furnace is filled with coal-ashes. A water-pan above the fire-pot is fed from an external communicating vessel.

Hot-bed Frame. The structure of sides and ends on which the sash of a hot-bed rest.

Hot-blast. A blast of air heated previous to its introduction into the smelting-furnace.

The process was invented by Nielson, of Glasgow, Scotland, and patented in 1828.

In 1845, Budd patented in England the utilization of the heated gases from the blast-furnace for heating the blast. By means of the hot-blast, anthracite coals were used successfully in smelting iron in Wales, in 1837, and at Mauch Chunk, Pennsylvania, in 1838, 1839.

Hot-blast Fur'nace. The temperature of the air, previous to its being thrown upon the charge in the furnace, is raised to about 600° in an outer chamber or in a series of pipes. These are variously arranged.

In that illustrated (*A*, Fig. 2588), the air is first condensed in an exterior chamber, whence it is forced into the pipe *a* within the reverberatory furnace *b*. Branches from this pipe terminate in the tuyeres on each side of the furnace, which has a separate fireplace.

In Staffordshire, the hot-air apparatus is at the mouth of the furnace, and consists of an exterior and interior tube, the former closed and the latter open at each end. The annular space between them is connected by cross-pipes; through these the air is impelled and passes thence to the tuyeres.

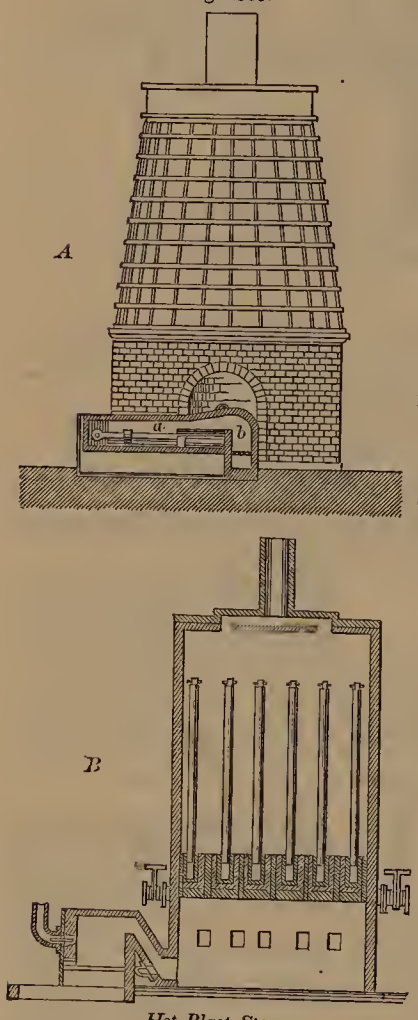
In 1834 M. Dufrenoy reported to the French government the results reached at the Clyde iron-works, which were as follows: —

For the year . . .	1829	1831	1833
Temperature of blast .	Cold	450° F.	612° F.
Coal used per ton of iron.	As coke.	As coke.	In raw state.
For fusion, cwt. . .	133	86	40
For heating air, raw coal	nil	5	8
For blowing engines, coal	20	7	11
	153	98	59
Cwt. limestone per ton of iron	10½	9	7

Besides this advantage, the make was increased by more than one third, and a blowing engine, which only supplied three furnaces with cold blast, was equal to four when the air was heated.

Player's stove (*B*, Fig. 2588) for heating furnace-blasts (English) is so constructed as to use the waste gases from blast-furnaces, drawing them by means of a steam-jet into a stove, where they are consumed to heat the air-blast.

Fig. 2588.



Hot-Blast Stove.

The stove consumes the gas in a separate chamber from that containing the pipes to be heated; air to support combustion is allowed to enter, and the heated fumes escape through a series of narrow slots into an air-tight chamber having a damper on the top and containing a series of vertical reverting pipes through which passes the blast to be heated. As the highly heated fumes will not again ignite without a fresh supply of oxygen, the cast-iron blast-pipes remain uninjured under a heat of 1100° or 1200°.

An auxiliary fireplace for burning coal is shown attached to the hot-blast stove. From this fireplace a flue conducts the flame, smoke, and gases from the blast-furnace into the chamber where the combustion is completed. Attached to the end of this fireplace, and connected with flues at the furnace-top, is a branch gas-pipe with a small steam-jet placed near its orifice to create a partial vacuum. This draws the gases down from the furnace-top and forces them into the stoves, where they are burned. The gas-pipe and jet may be placed at the bottom end of the combustion-chamber of the hot-blast stove.

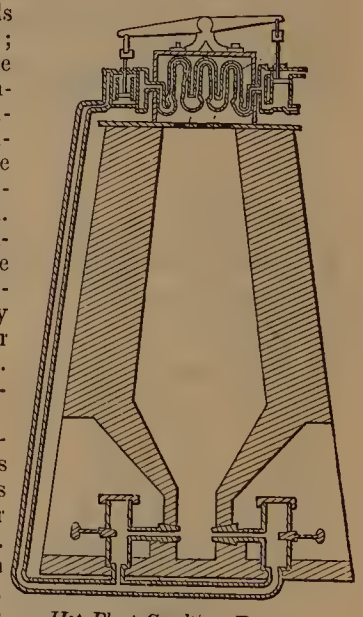
The arrangement of pipes is in six treble rows, each stove contains 18 pipes, 8 inches in diameter by 14 feet high, giving about 1,000 square feet of heating surface. The pipes are disposed three in a row; the blast thus passing up and down three times, discharging into connecting chambers in the roof of the combustion chamber below.

Since 1840, the blast has been gradually made hotter and hotter, and the means of economically and regularly giving the air a temperature of 1,000 or more degrees have attracted much attention.

Cowper's patent is founded on the Siemens regenerative principle, a cellular mass of brick-work being first raised to a high heat, and this heat then imparted to the blast, which is made to pass through it, while a similar mass of brick-work is being heated, ready for use as soon as the first shall have become partially cooled. Whitwell makes his brick-work into large compartments instead of cellular. It is claimed that the blast can be heated to 1800° by this stove, and a regular working heat of 1400° be steadily maintained. To estimate properly the great importance of improved devices for heating the blast, it should be remembered that for every ton of materials charged in at the tunnel-head at least three tons' weight of air is blown in at the bottom through the tuyeres; it can therefore be readily understood how desirable it is that this air should be put into the furnace already heated, instead of throwing the work of heating it upon the fuel in the furnace, which should find abundant employment in smelting the ore only.

In McDowell's apparatus (Fig. 2589), the air-engine and air-pump pistons are connected to opposite ends of a walking-beam; both have double action, and are connected to a serpentine pipe in a chamber at the top of the cupola and communicating therewith. The pump and engine have suitable valves, and communicate respectively with the outer air and the blast-pipe. See also BLOWING-APPARATUS.

Fig. 2589.



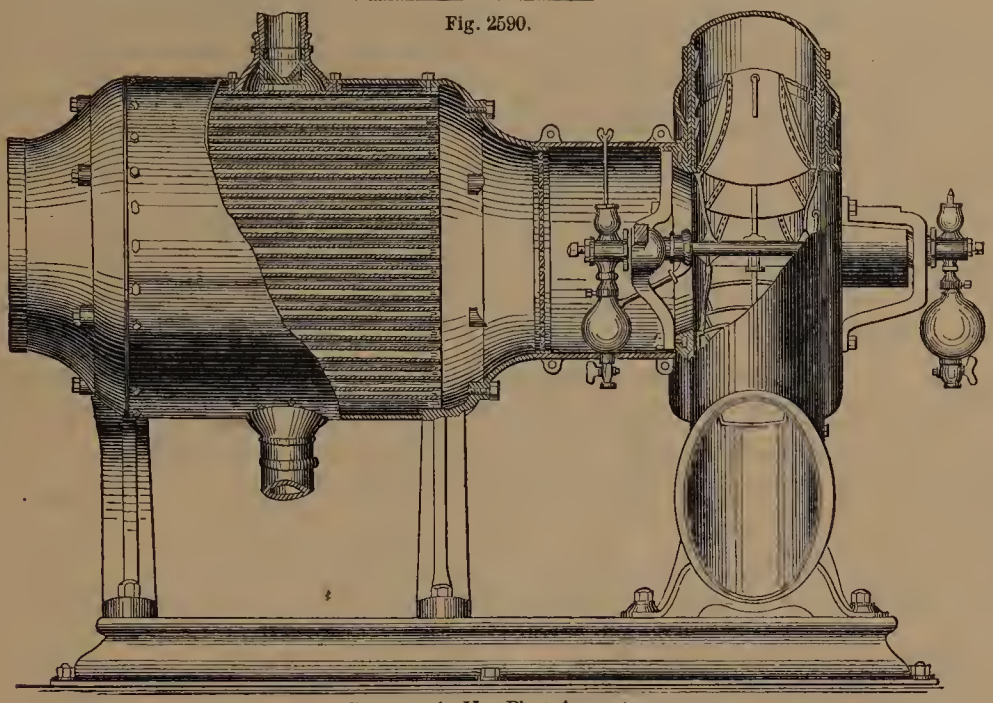
Hot-Blast Smelting-Furnace.

Fig. 2590 represents Sturtevant's hot-blast apparatus for drying timber and other materials. In this, air is drawn in by a suction fan, and passed through a series of longitudinal tubes inserted in a cylinder heated by exhaust steam from the engine, whence, at a temperature of 150° to 200°, it is conducted to the drying-room. See LUMBER-DRYER.

Hotch'ing-tub. (*Metallurgy.*) A tub and sieve in which lead ore is agitated in water to separate the metallic and refuse parts. It is preliminary to the *buddle*. See HUTCH.

The *cuttings* are detained by the sieve; the *smeddum* passes through into the bottom of the box.

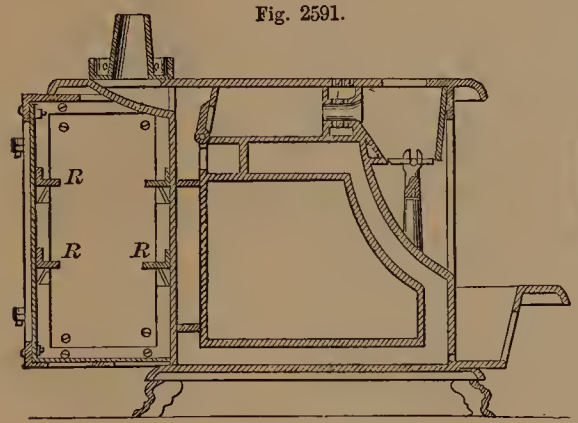
Fig. 2590.



Sturtevant's Hot-Blast Apparatus.

Hot-clos'et. 1. One attached to a stove to keep victuals or plates warm. That shown has ledges *R R* for shelves in the closet.

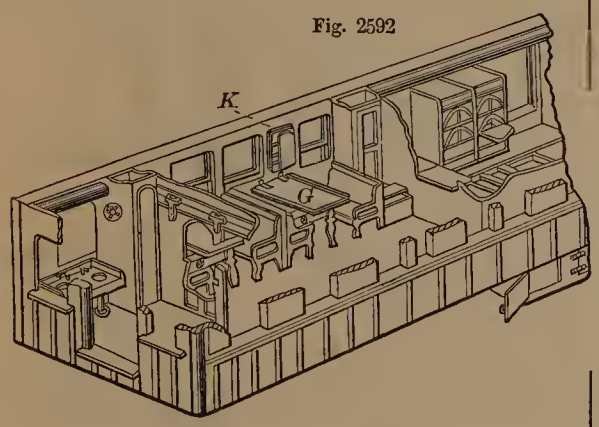
Fig. 2591.



Cooking-Stove with Hot-Closet.

2. (*Candle-making.*) A chamber in which candle-molds are kept at a heat of 150° Fah., previous to pouring, to prevent the chilling of the stearic acid. The steam heat is applied dry.

Fig. 2592



Hotel-Car.

Ho-tel'-car. One arranged for affording meals to passengers on board while on a journey. Closets *K* are arranged between each pair of windows. A water-tank *B* is placed at the upper part of one side, to which also tables *G* are attached, and part of the car is partitioned off as a kitchen, with a cooking-range. A provision chamber *E* is attached beneath the floor of the car.

Hot-flue. A chamber, heated by hot-air pipes, in which printed calicoes are dried.

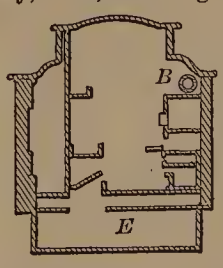
A drying-chamber for cloths or paper, starch, etc.

Hot-gild'ing. A name applied to amalgam gilding, in which the mercury is driven off by heat.

Hot-house. 1. (*Pottery.*) A room where strong heat completes the drying of green ware, previously to placing in seggars and firing in a kiln.

2. (*Horticulture.*) A plant-house where a relatively high artificial temperature is maintained in order to facilitate vegetable growth.

The botanic gardens of Pisa, Padua, and Bologna, established from 1544 to 1568, did not contain hot-houses. In the thirteenth century, however, Albertus Magnus, who was equally active and influential in promoting natural knowledge and the study of the Aristotelian philosophy, possessed a hot-house in the convent of the Dominicans at Cologne. This celebrated man, who had already fallen under the suspicion of sorcery on account of his speaking-machine, entertained the king of the Romans, Wilhelm of Holland, on the 6th of January, 1249, in a large space in the convent garden, where he kept up an agreeable warmth, and preserved fruit-trees and plants in warmth throughout the winter. This entertainment was exaggerated into a tale of wonder in the chronicle Joannis de Beka, written in the fourteenth century.



There is no evidence that forcing-houses were used in ancient horticulture. The conduction of heat by caliducts for baths and apartments was well known, but it does not appear that these facilities were used for floricultural purposes.

Regular hot-houses are of late introduction in our botanic gardens. Ripe pineapples were first obtained in Europe at the end of the seventeenth century. Linnæus states that the first banana which flowered in Europe was in Vienna, in the garden of Prince Eugene, in 1731.

The accordant accounts of Hernando Cortes, in his reports to the Emperor Charles V., of Bernal Diaz, Gomara, Oviedo, and Hernandez, leave no doubt that at the time of the conquest of Montezuma's empire, there were in no part of Europe menageries and botanic gardens which could be compared to those of Huaxtepec, Chapultepec, and Tezcuco.

Hot-press. (*Paper.*) A means of calendering and smoothing paper by subjecting it to heavy pressure between glazed boards; a hot iron plate is placed at every 20 sheets or so, to heat the pile.

Hot-saw. A buzz-saw for cutting up hot bar-iron, just from the rolls, into bars or into pieces for being piled, reheated, and rerolled.

Hot-short. (*Metal-working.*) Iron which is disposed to crack or break when worked at a red heat, and is difficult to weld, is said to be hot-short. It is frequently the presence of sulphur to the extent of, say, 0.033 per cent, which makes it brittle.

Hot-shot. Cannon-balls made red hot in a furnace in order to fire wooden structures into which they are thrown.

Hot-wall. A wall with included flues to assist in ripening the fruit of trees trained against it.

In some cases the wall is traversed by a number of flues leading from a furnace or furnaces; in others the entire wall is double, the included space being crossed occasionally by ties which keep the two walls together.

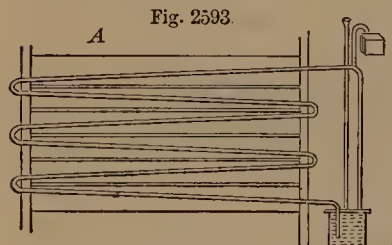
Its use is principally in northern countries in ripening fruits which do not mature in the natural temperature of the latitude, such as the peach, nectarine, and apricot in England.

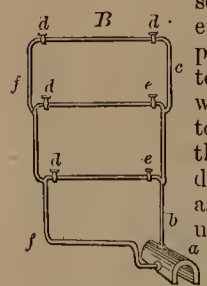
Hot-wa'ter Fau'cet. The faucet of a bath, tank, beck, vat, or wash-basin, which admits the hot water, for scalding, infusing, washing, leaching, or other purpose.

Hot-wa'ter Heat'ing-ap'pa-ra'tus. A means of heating by the passage of hot water through pipes in rooms.

Bonnemain appears to have been the first to introduce the circulation of hot water in a system of pipes, as a means of warming apartments and buildings. He devised it in 1777, in connection with his incubator. See CALORIFÈRE; INCUBATOR. The egg-chamber had several stories, and each was traversed by one or more bends of the pipes, which were so arranged as to have a constant inclination, by which the cooler water descended to the boiler. The velocity of the current depends upon the difference in temperature of the ascending and descending columns.

Fig. 2593.





Hood's Heater.

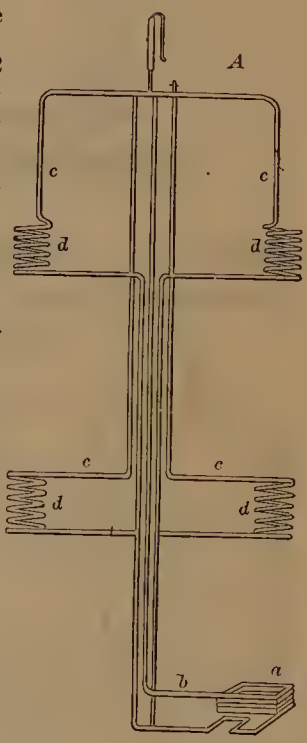
This is shown at *A* (Fig. 2593). Hot-water heating-apparatus on the *low-pressure* system employs a heat at or below the boiling point. By the *high-pressure* system the heat is increased to 350°, and the water has a tendency to form steam of 70 pounds pressure to the square inch.

Bonnemain's system was of the low-pressure kind, and this class of heaters has been much improved by Hood; see his "Practical Treatise on the Warming of Buildings by Hot Water" (London, third edition, 1855).

Hood's apparatus for heating (*B*, Fig. 2593) had several variations, but the main features are similar to those of Bonnemain. It consisted of a boiler *a* and ascending pipe *b c*, with branches to each story, regulated by faucets *d e*. The descending pipes *f* carry back the cooler water. By another system, each story has its own ascending and descending pipes, with separate connection to the boiler. An air-faucet at top is necessary to allow escape of air from the pipes when starting up.

The boiler must be sufficiently strong to bear the hydrostatic pressure of the column of water. A boiler, 3 by 2 and 2 feet deep, with a pipe 28 feet high proceeding from it, will sustain a pressure of 66,816 pounds.

Fig. 2594.

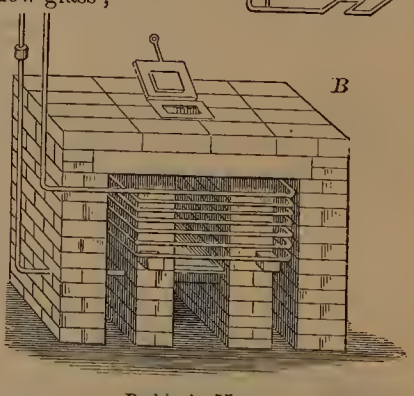


The size of the boiler will depend upon the extent and size of pipe, but one square foot of boiler fire-surface is allowed to every 50 feet of 4-inch pipe, the temperature of which is to be kept 140° above that of the surrounding air.

The quantity of pipe is thus stated in his work above referred to: —

"Allowing 3½ cubic feet of air for each person in the room or hall, as the quantity per minute which is to be warmed, and one cubic foot per minute as the quantity cooled by each square foot of window-glass; then ascertain the whole quantity of air that is to be heated, and apply the following rule:

"Multiply 125 (the excess of temperature of the pipe above the surrounding air) by the difference between the temperature at which the room is to be kept when at its maximum, and the temperature of the external air; and divide this product by the difference between the temperature of the pipes and the proposed temperature of the room; then the quotient thus obtained, when multiplied by the number of cubic feet of air to be warmed per minute, and this product divided by 222 (the number of cubic feet of air raised 1° per minute by 1 foot of 4-



Perkins's Heater.

inch pipe), will give the number of feet in length, of pipe 4 inches in diameter, which will produce the desired effect." For 3-inch pipes multiply the said number by 1.33; for 2-inch pipes multiply by 2. The given diameters of the pipes are outside measurement. Small pipes have a relatively larger area of heating surface.

Perkins's high-pressure hot water heating-apparatus (*A B*, Fig. 2594) consisted of a continuous wrought-iron pipe, which formed a coil *a* in the furnace, and passed from story to story of the building, being amplified into coils at special points, as in the apartments to be warmed. The pipe was ½ inch in internal diameter and ¼ inch thick, and about ⅙ of the length of the pipe formed the furnace coil. The heated water in the coil *a* becomes charged with minute globules of steam and ascends in pipe *b*, from whence it is distributed right and left to the apartments by branch pipes *e* and coils *d*. The descending pipes carry the hot water to the story below, where it heats the apartments by means of other coils *d*, which discharge into the descending pipes, by which the water again reaches the furnace coil.

A common arrangement is shown at *B* in the figure; the pipe is coiled around the inner casing of the furnace, coming in contact with the fire only in front; this casing and the top of the furnace are composed of fire-brick, the fire-grate being in the center and elevated a foot or so from the floor; fuel is supplied through a hole in the top. The smoke passes through the chamber containing the pipes, and escapes through a hole in the back.

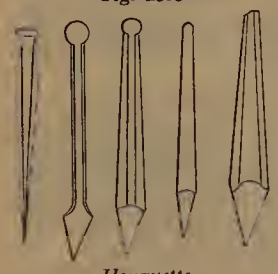
Hot-wa'ter Pipe. (*Steam.*) The pipe which receives the hot water from the hot-well and discharges it.

Hot-wa'ter Pump. (*Steam-engine.*) A pump which raises water from the hot-well of a condensing steam-engine and discharges it into the feed-water cistern, whence it passes in graduated quantities to the boiler. See also FEED-WATER APPARATUS; INJECTOR.

Hot-well. A compartment in the cistern in which the condenser and air-pump of a condensing-engine are submerged, and from which the warm water is drawn for the supply of the boiler.

The submerged *injection-chamber* and the *air-pump* connect by a passage, whose valve opens during the ascent of the piston and closes during its descent. The uncondensed steam, the air, and the water of condensation pass by this passage to the air-pump, through the bucket of the latter as it descends, and are ejected into the *hot-well*. The heated water is drawn thence to supply the boiler. See AIR-PUMP; CORNISH STEAM-ENGINE.

Fig. 2595.



Houguette.

Hou-guette'. The etching-needle of the marble-worker. Fig. 2595 shows several different forms.

Hound'ing. (*Nautical.*) That portion of a mast between the deck and the top of the hounds.

Hounds. 1. (*Vehicle.*) Side bars which strengthen certain portions of the running-gears of a vehicle.

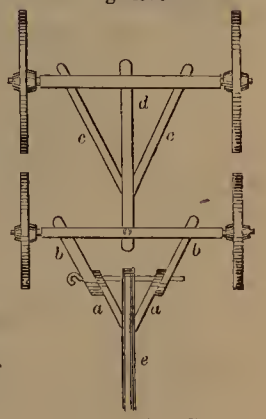
a, tongue-hounds.
b, hounds.
c, hind-hounds.
d, coupling pole or *reach.*
e, tongue.

In wagons, the *hounds* of the fore-axle pass forward and on each side of the tongue, to which they are secured by the tongue-bolt.

The hounds of the hind-axle unite and are fastened to the coupling-pole by the coupling-pin.

2. (*Nautical.*) Projections on the mast-head to support the trestle-trees and top. Cheeks fayed to the sides of the mast-head.

Fig. 2596.



Wagon Running-Gears.

Hour-cir'cle. (*Globes.*) A small brass circle fixed to the north pole, divided into twenty-four hours, and furnished with an index for pointing them out.

Hour-glass. A glass having two bulbs and a connecting opening through which the sand in one bulb runs into the other. The amount of sand and size of the opening are such that a given amount of time is consumed in the passage.

On an ancient bas-relief at Rome an hour-glass is placed in the hands of Morphens, and Athenæus says that the ancients carried portable hour-glasses with them as measurers of time.

Glasses of this description are yet used for marking small periods of time; such as, —

1. The three-minute glass, or *egg-glass*, in which the sand passes in the time mentioned.

2. The half-minute glass used in ascertaining the rate of a ship by the *log*.

The line is knotted at such intervals that the spaces bear the same relation to a nautical mile that the half-minute does to an hour. That is, they are $\frac{1}{120}$ of a nautical mile apart, — about $50\frac{7}{10}$ feet.

The line being on a reel, the *chip* is thrown overboard, and, catching in the water, causes the line to run off the reel. When the *stray-line* has run out, the half-minute glass is turned, and the number of knots on the string which pass through the seaman's hand indicates the number of nautical miles per hour that the vessel is sailing.

The use of the hour-glass in calculating a ship's course is much older than that of the log, the rate being estimated by the eye. The hour-glasses, *ampolettas*, used in the expedition of Columbus, ran out in half an hour, so that the interval of a day and a night was reckoned at 48 ampolettas, and so the journal — log-book — recorded. The log is not mentioned. It was used in the Pacific by Magellan. See LOG.

The horoscopus in the Egyptian processions carried with him the measurer of time, an hour-glass.

The "Sûrya Siddhânta," a Sanscrit treatise on astronomy, treats of the "stringed sand receptacles" for measuring time; these were doubtless of the general character of our hour-glasses.

Hour-glasses were unknown in China formerly, and of late are mentioned by them as of importation from the West.

A tradition of the Middle Ages relates that the sand-glass (sablier) was invented by Liutprand, a monk of Chartres, who reinvented the art of making glass after the secret had been lost for ages.

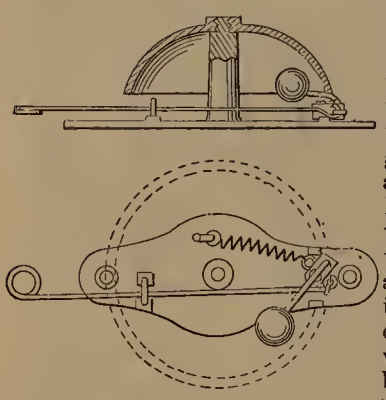
Shortly after receiving the famous clepsydra from Haroun al Raschid, Charlemagne caused a monster sablier to be made, which required turning but once in 12 hours. It had the horary divisions marked upon the outside.

The hour-glass or half-hour glass was a regular part of pulpit furniture in the sixteenth century, to denote to the preacher when it was time to close. It was used in Massachusetts two centuries since for the same purpose.

Hour-hand. (*Horology.*) That one which shows the hour on a watch-dial, performing its revolution in 12 hours.

House-bell. A form of bell for doors of houses; formerly a bell suspended by a coiled strip which gave it the repetitive action when the wire was once pulled; now more usually a form of gong which gives a single sound. In the example, the bell is screwed to a central post and the clapper is fastened to an oscillating block which is moved by a rod and retracted by a spring.

Fig. 2597.



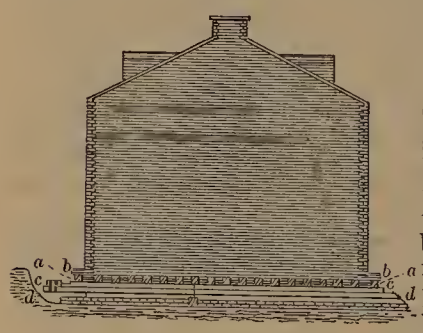
House-Bell.

House-boat. A boat used as a dwelling. Common in China, and once common on our Western rivers.

House-line. (*Nautical.*) Or *housing.* A fine line having three strands, smaller than rope-yarn and used for seizings, fastening thimbles of sails to their ropes, etc.

House-mov'ing. The operation of removing small or moderate-sized frame structures from one locality to another is a task of comparatively easy accomplishment. The house is supported on beams laid in the direction to be taken, beneath which rollers are placed and the power of tackle or of a capstan applied to a rope properly secured to or around the house.

Fig. 2598.



House-Moving.

The case of brick buildings, especially those of large dimensions, presents more difficulty.

A foundation is first prepared on the new site. A trench is next cut around the outside of the house, and the earth is also removed from the interior, so as to expose the foundation. Through this, openings are made, into which are inserted, at intervals of about three feet, at right angles to the direction that the house is to be moved, stout beams *a* which project about three feet beyond the walls at each end. Under each of these projecting ends a screw-jack is placed, resting on a firm foundation, and, by the operation of these, the beams *a* are brought up into close contact with the superstructure, the intermediate masonry being removed. Above and resting upon the beams *a* are placed beams *b*, through openings made in the walls for the purpose, and below, transversely to them and in the direction the house is to be moved, two beams *c d* are placed under each end wall; the lower of these has a tongue, and serves as a guide for the upper, which is grooved, and slides upon it. The two surfaces of contact are greased, and a powerful screw-jack, butting against the beams *c*, is fixed horizontally to each of the beams *d*, and operated until the structure is moved the distance which the limit of motion of the screw-jacks allows. They are then unfastened and the operation repeated. By successive additions to the length of the lower beams *d*, this may be continued until the house is moved any required distance.

House-lifting by screw-jacks is now an important business.

This process requires great care and attention, as it is obvious that an inequality in the movement of the numerous screw-jacks tends to crack the walls.

Hous'ing. 1. (*Railway.*) One of the plates or guards on the railway carriage or truck, which form a lateral support for the axle-boxes, and in which they slip up and down as the springs alternately contract and expand. Also called *pedestals, horn-plates, jaws, axle-guards.*

2. The framing holding a journal-box; as, one of the standards holding the journal-boxes of the rolls in a rolling-mill.

3. The uprights supporting the cross-slide of a planer.

4. (*Carpentry.*) The notches in an object for the insertion of another piece; as, —

a. (*Stair-building.*) Notches in the string-boards for the ends of the steps.

b. (*Artillery.*) A prismatic groove in the axle-tree of a gun-carriage for the cheeks of the transom.

Notches in the *brackets* to fit on the axletree bed, and so on.

5. (*Nautical.*) *a.* That portion of a mast which is included between the keelson and the surface of the upper deck.

b. A covering or protection, as of a ship's deck, when laid up in ordinary or under stress of weather, as in the Arctic regions.

c. A cord made of three small yarns and used for seizings.

6. (*Saddlery.*) *a.* A cloth extending rearwardly from the saddle and covering the loins of the horse.

b. The pad of a collar.

c. A hood or covering piece for the collar.

Hous'ing-bear'ers. (*Metal-working.*) The frame in which the rollers of an iron-rolling mill are set. *Housing-frames.*

Hov'el. (*Porcelain.*) A conoidal structure of brick, 40 feet in diameter and 35 feet high, around which the *ovens* or firing-kilns are clustered.

How'el. (*Coopering.*) A plane with a convex sole, used for smoothing the insides of barrels and casks, making the smooth circle at the croze, and also the chamfer on the inside of the chine.

How'it-zer. A cannon, differing from ordinary guns in being shorter and lighter in proportion to its bore, and used for throwing hollow projectiles with comparatively small charges. A 6-pdr. gun weighs 100 pounds more than a 12-pdr. howitzer. Their charge of powder for a 12-pdr. field howitzer is ¾ pound of powder; that for a 12-pdr. mountain howitzer is ½ pound of powder. A smaller chamber at the bottom of the bore receives the powder.

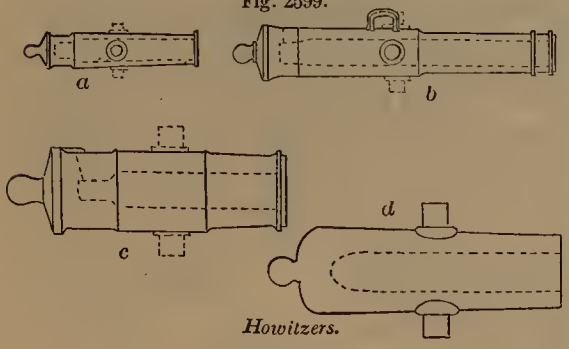
a, mountain-howitzer.

b, field-howitzer.

c, siege-howitzer, model of 1850.

d, the siege-howitzer, 1861, has a chamber the size of the bore. See MOUNTAIN-HOWITZER.

Fig. 2599.



Howitzers.

How'ker. (*Vessel.*) A Dutch vessel with two masts. The *hooker* is an Irish fishing-smack.

Hoy. (*Vessel.*) A one-masted coasting-vessel, used before the era of steamboats for conveying passengers and goods between places, or as a tender upon larger vessels in port.

Hub. 1. A fluted screw of hardened steel, adapted to be placed on a mandrel between the centers of a lathe, notched to present cutting-edges, and to be used in cutting screw-tools, chasing-tools, etc. The chasing-tool, for instance, is laid on the rest and pressed forcibly against the *hub*. (Fig. 2600.)

Fig. 2600.

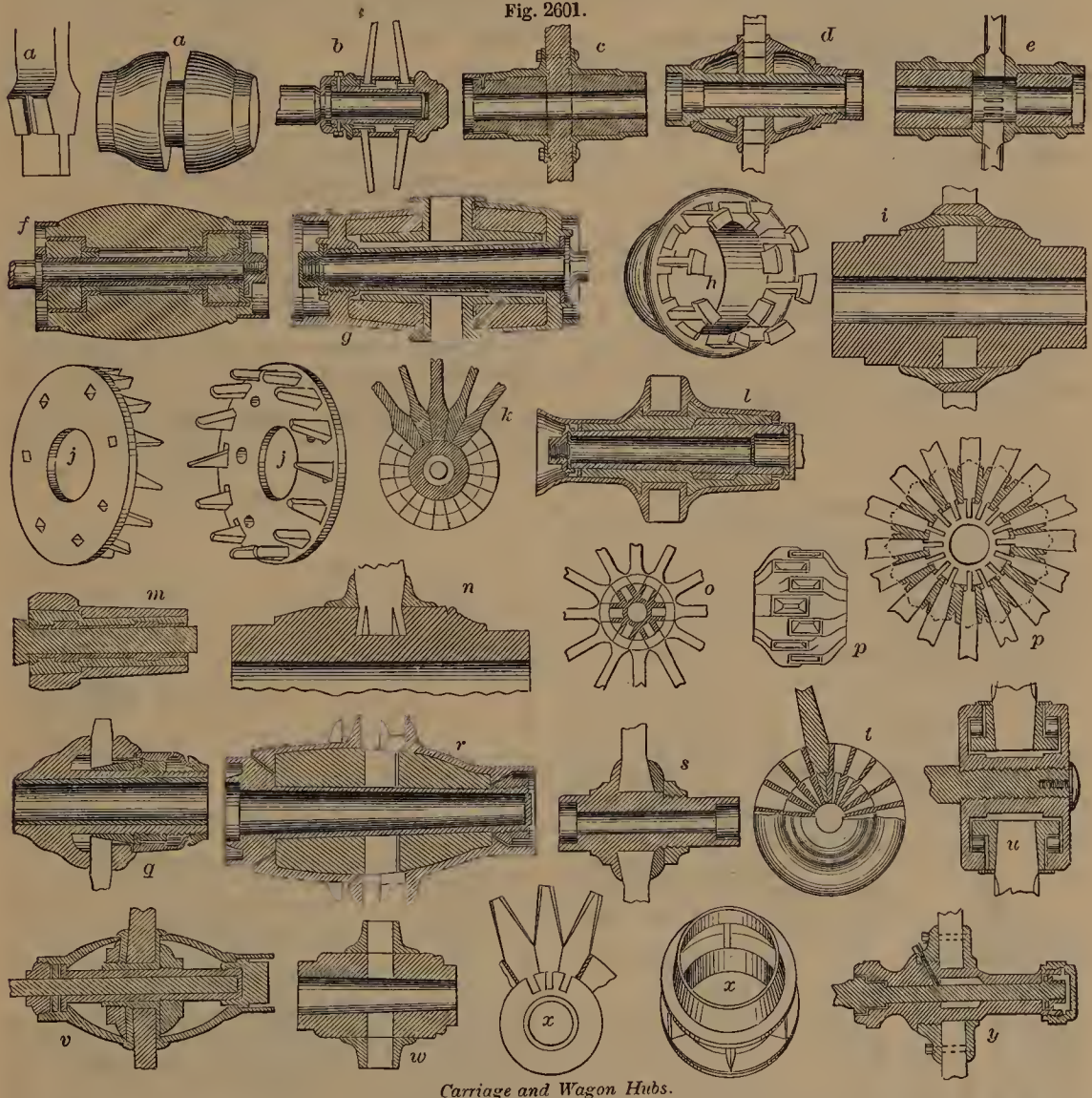
Hub.

2. (*Die-sinking.*) A cylindrical piece of steel on which the design for a coin is engraved in relief. The engraving is done while the steel is soft, and, after hardening, the *hub* is used to make *matrixes*, from which are made *punches* which impress the *dies* used in *coining*. (See MATRIX; PUNCH; DIE.) The *hub* or the *punch* is pressed upon the softened steel *blank* in a powerful screw-press; and the *matrix* or *die* is removed, annealed, and replaced several times, as the pressure has the effect of hardening.

3. (*Vehicles.*) The central portion of a wheel which is slipped upon the *arm* of the axle, and in which the spokes are set radially. The *nave*.

A bronze hub, with peripheral sockets for the reception of the spokes, is in an ancient Scythian chariot, found in Egypt, and now in a European museum, probably that of Berlin. It is supposed to have been carried to Egypt as a trophy by a conqueror of that nation. See CHARIOT.

Fig. 2601.



Carriage and Wagon Hubs.

a is a hub having a circumferential groove, in which the shoulders form a continuous band, while the tenons of the spokes set in mortises in the bottom of the groove.

b is a metallic hub, one portion of which forms the axle-box around which are the nuts on the inner ends of the double set of iron spokes.

c has two circumferential metallic bands, between which the spokes, forming a solid circular series, are clamped and bolted; the clamps also holding the wooden sleeves around the axle-box.

d. Around the hollow axle-box are clamped two hollow disks, which have projecting lugs to form the spoke mortises.

e has a metallic shell having a depressed center, in which the spoke mortises are formed, and has tubular cases driven in from the ends.

f has rubber disks around the axle-box at each end of the hub.

g has a central disk forming the spoke-sockets, and this is clamped by two outer disks with intervening hollow cones

h has two hollow shells with T-shaped lugs, which interlock to form spoke-sockets.

i has two overlapping mortised hub-bands.

j has two metallic disks, with projecting lugs to form spoke-mortises; the disks are drawn together with bolts.

k has a grooved hub with alternate projecting lugs to form dodging mortises.

l has a soft metal or plastic material run in between the axle-box and the shell of the hub.

m resembles the previous in some respects.

n. The hub has a dovetail mortise and wedges to prevent the withdrawal of the spokes, and beveled metallic bands to form seats for the spokes.

o has a mortised hub and metallic bands to clamp the spokes, which form an arch around the hub.

p has a hub-band with staggering metallic sockets, and hub with mortises for the spoke-tenons.

q has wedges against the inner ends of the spokes; these are driven outward by the inner hub-band, which screws on the sleeve of the outer portion of the hub-band.

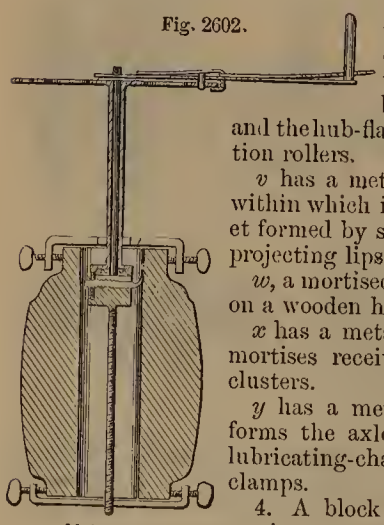
r has a metallic shell with staggering mortises and projecting lips to support the spokes.

s has a metallic hub formed in three parts, — the axle-box and inner hub-band, the outer hub-band, and the clamping-nut. The circular spoke-groove has a dovetail form.

t has a metallic band with beveled mortise.

u. The end flanges are screwed on the axle-arm. The inner ends of the spokes are secured in a mortised flange-ring, between which and the hub-flanges are anti-friction rollers.

Fig. 2602.



Hub-Borer.

v has a metallic hub-shell within which is a spoke-socket formed by sleeve, nut, and projecting lips.

w, a mortised metallic band on a wooden hub.

x has a metallic band whose mortises receive the spokes in clusters.

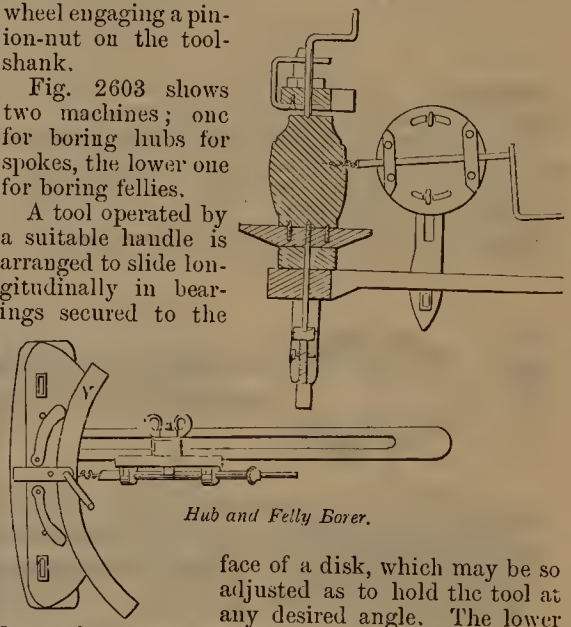
y has a metallic hub which forms the axle-box, and has a lubricating-chamber and spoke-clamps.

4. A block for scotching a carriage or car wheel.

Hub'ble-bub'ble. An onomatopoetic word. A pipe in which the smoke is drawn through water.

Hub-bor'er. (*Wheelwrighting.*) An implement or machine for boring hubs for the boxing or the spokes. That in Fig. 2602 is for the former purpose. Clamps at each end of the hub form guides for the central shaft, which has a box to carry the cutter, whose progression is obtained by the thread on the shaft. The cutter has a threaded shank, and is fed outward to enlarge the diameter of the bore by the rotation of the tube, which has a crown-wheel engaging a pinion-nut on the tool-shank.

Fig. 2603.



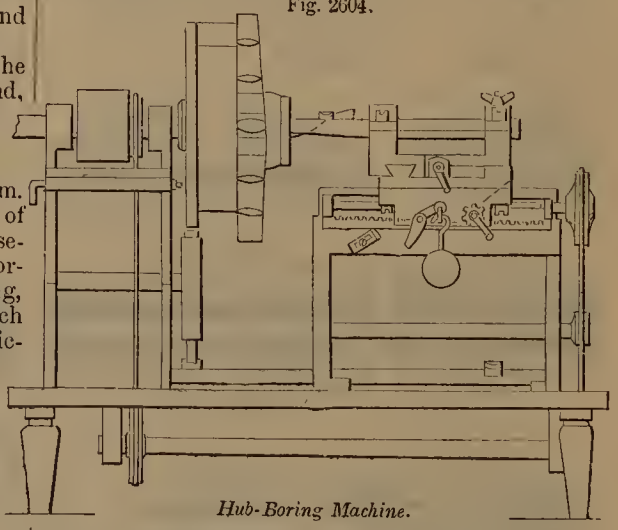
Hub and Felly Borer.

Fig. 2603 shows two machines; one for boring hubs for spokes, the lower one for boring fellies.

A tool operated by a suitable handle is arranged to slide longitudinally in bearings secured to the face of a disk, which may be so adjusted as to hold the tool at any desired angle. The lower figure shows a sliding cross-piece provided with two arms which are adjusted to hold the felly *Y* in position while being bored by a set screw having a handle.

Hub-bor'ing Ma-chine'. The machine (Fig. 2604) bores the hub by the rotation of the latter rather than of the former. The boring-tool is mounted upon a horizontal bed, which is susceptible of an oscillating motion about a center for the purpose of allowing the tool to be set at any desired angle. With this bed is combined a laterally adjustable tool-holder and a longitudinally adjustable carriage. The carriage is provided with a contrivance for throwing it in and out of gear, with a feeding-screw for the purpose of feeding the tool up to its work with a slow motion, and retracting with a quicker motion.

Fig. 2604.

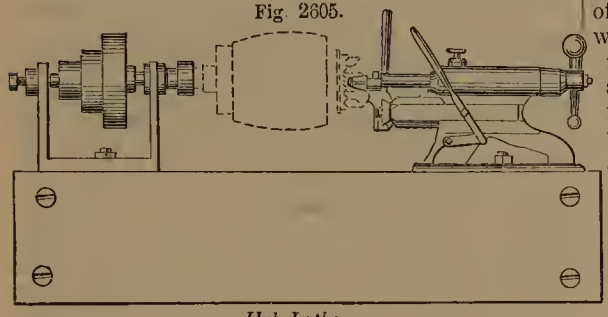


Hub-Boring Machine.

Hub-cen'ter-ing Ma-chine'. (*Wheel-making.*) A machine in which a hub is chucked while the hole for the axle-box is reamed out concentric with the outside shape. A similar mode is adopted for holding the hub while setting the boxes therein.

Hub-lathe. (*Wheelwrighting.*) A form of lathe for turning carriage and wagon hubs. In the example, the cutter is held and fed to its work by a double slide, and its lateral movement is regulated by the adjustable stop attached to the cross-head of the double slide.

Fig. 2605.



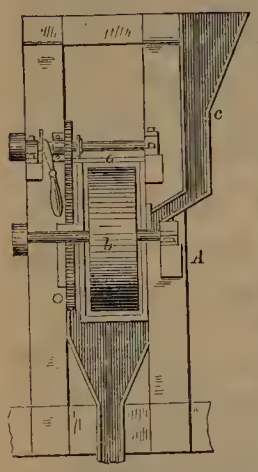
Hub-Lathe

Hub-mor'tis-ing Ma-chine'. (*Wheelwrighting.*) A machine in which a wheel-hub is held upon a mandrel or stake, so disposed that a reciprocating chisel may cut therein the mortises for the spokes. The hub is dogged or clamped so as to prevent rotation while the mortise is being cut, and is then rotated a determinate number of degrees to present the next spot to the cutting-tool.

Hub-turn'ing Ma-chine'. (*Wheelwrighting.*) A form of lathe specially adapted for turning hubs for vehicle wheels.

Huck-a-back. (*Fabric.*) A table linen or toweling having the weft alternately crossed, so as to make it thick at certain points to roughen the surface by producing a raised pattern.

Fig. 2606



Huf'fing. A process of ornamenting gilded leather.

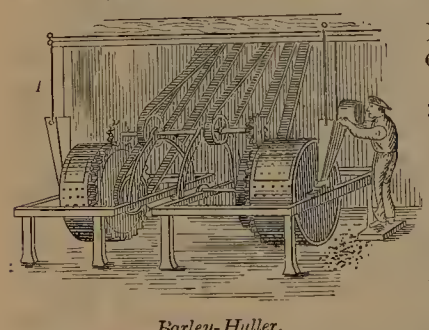
Hulk. (*Nautical.*) The hull of a vessel not seaworthy, and moored in port for hospital, guard, convict, quarantine, custom-house, storage, victualing, or other purposes.

A *sheer*-hulk is one fitted with *sheers* for masting and dismasting vessels.

Hull. (*Shipbuilding.*) The body of a vessel, exclusive of its masting, rigging, etc. A dismantled *hull* is a *hulk*.

Hull'er. See HULLING-MACHINE.

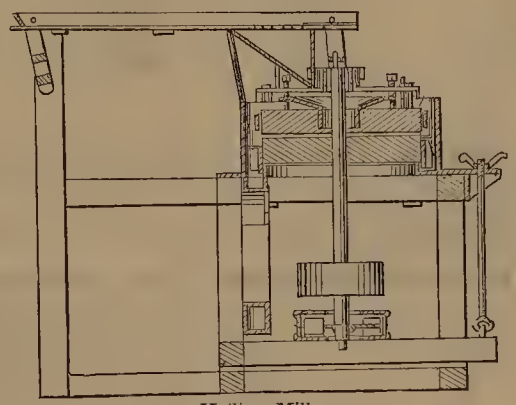
Hull'ing-ma-chine'. (*Agriculture.*) A device for removing the cuticle from grain, and for breaking it without reducing it to the condition of meal. In the time of Pliny a mortar was employed for this purpose, sand or pieces of brick being placed therein to assist the trituration. Foreign substances, including the husk and bran, were removed by sifting. For this purpose, the Egyptians used sifters made of papyrus and rushes, the ancient Spaniards of flax, and the Gauls invented sieves of horsehair.



Barley-Huller.

The Scotch pearl-barley mill is shown in Fig. 2606, *A* being a section of the cylinder, and *B* a perspective of the machines in operation. It consists of a drum *a*, which is rotated by gearing, and within which a circular grindstone *b* is caused to revolve more rapidly by belting. The grain is fed through a hopper *e* opening axially into the drum, and is removed by a sluice at its side. The drum is lined with sheet-iron, perforated with small holes, which serve to remove the skin and a portion of the outer substance of the grain, bringing it to a spheroidal shape; whence the name of *pearl* barley. *Pot* barley has merely the outer skin removed.

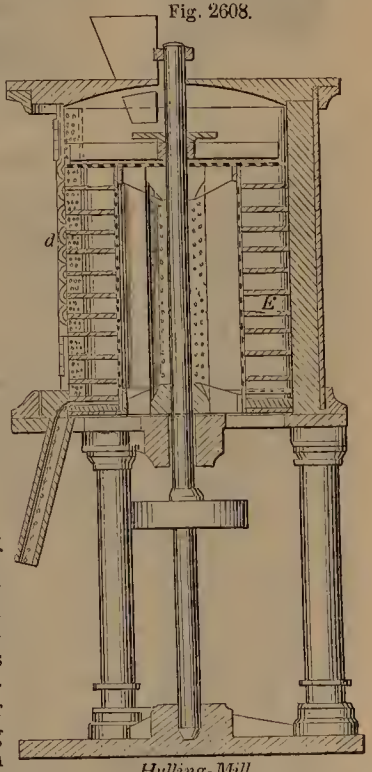
Fig. 2607.



Hulling-Mill.

Fig. 2607 illustrates a machine in which the hulling process is effected between two horizontal stones adjustable relatively to each other, so as to give the requisite trituration without pulverizing the grain.

Fig. 2608.



Hulling-Mill.

The machine shown in Fig. 2608 has a revolving wire-gauze cylinder, provided with rough-surfaced shelves *E E*, on to which the grain is successively conducted by conduits *d*, in its downward passage from the hopper. An internal fan eliminates the husk, etc., during the process.

There are some other varieties of machines which depend partly upon percussion, an example of which has a series of the ordinary triangular saw-files projecting radially from an axis rotating at high speed within a cylindrical casing. See HOMINY-MACHINE.

Human, and other Animal, Parts and Features represented in Mechanics.

Ankle.	Gullet.	Poll.
Arm.	Gum.	Rib.
Back.	Hair.	Seat.
Beard.	Hand.	Shank.
Belly.	Head.	Shoulder.
Body.	Heart.	Side.
Bosom.	Heel.	Skin.
Breast.	Hip.	Sole.
Breech.	Jaw.	Spine.
Butt.	Joint.	Step.
Cheek.	Knee.	Teat.
Claw.	Knuckle.	Throat.
Crown.	Leg.	Toe.
Diaphragm.	Lip.	Tongue.
Ear.	Lug.	Tooth.
Elbow.	Mouth.	Trunk.
Eye.	Muzzle.	Tusk.
Face.	Nail.	Vein.
Finger.	Neck.	Waist.
Foot.	Nipple.	Wrist.
Gland.	Nose.	
Groin.	Palm.	

Hum'bug. (*Menage.*) A nippers for grasping the cartilage of the nose. Used with bulls and other refractory bovines.

Hum'hum. (*Fabric.*) A plain, coarse, cotton cloth, made in India.

Hum'mel-ing-ma-chine'. A machine for breaking off the awns of barley. It consists of a vertical shaft provided with several beaters at several different levels and revolving

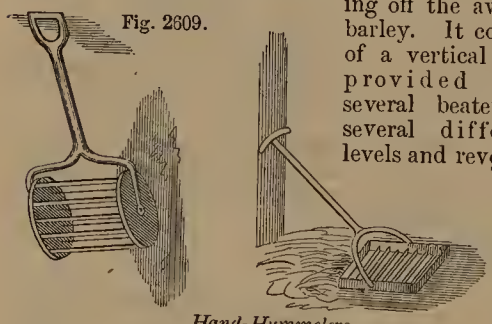


Fig. 2609.

Hand-Hummelers.

rapidly in a cylindrical case so as to beat the grain as it falls.

The operation is also performed in a thrashing-machine by putting the grain through a second time, substituting for the ordinary cover a tin case with teeth made by punching holes through it from the outside. Hand-hummelers or *aveling-machines* (Fig. 2609) are used upon the grain spread on the barn floor, being either rolled or dragged.

The Japanese hummel their rice in a mortar made of a section of a large tree hollowed out.

Hun-ga'ri-an Leath'er. (*Leather.*) A white leather originally made in and imported from Hungary, but now manufactured in other countries.

Mineral salts are substituted for vegetable extracts. The hides are first treated with a mixture of alum and common salt, by which a portion of the sulphate is converted into the chloride of aluminium. An excess of salt keeps the hides supple. The fleshing and scraping processes are proceeded with as in the ordinary modes of tanning, but the hair is removed by shearing instead of liming.

The first alum bath has, alum 7 pounds, salt 4½ pounds, water 8 gallons, for each hide of 85 pounds' weight. The temperature is raised to 120° F., and the sides are extended in the bath, hair side up. They are tramped while in the bath; this is three times repeated in warm liquor, the strength of the liquor being maintained. The skins then lie 8 days in the menstruum.

The skins are taken out, stretched, and shaken, and then treated by a saline bath as before, but only lying 24 hours in the liquor at the conclusion of the repeated tramping processes. The hides are then drained, partially dried, stretched, suspended by their edges, and exsiccated. See TAWING.

The skins are tramped and rolled till rendered supple, and are then ready for the oiling process.

The oiling material is a mixture of tallow and fish-oil, the ordinary *dubbing* of the American currier; this is spread by a mop on the flesh and the hair sides of the skins, which are made into a pile flesh side up.

An open charcoal fire is then lighted in the room, which is closed air tight, and after an interval, and the opening of the door for the escape of carbonic acid, the workmen enter, and grasping a skin by the ends hold it, flesh side down, over the charcoal fire, at the same time stretching it in all directions. As each side is *flamed*, it is laid on a table, the pile of warm and greasy hides being covered with a cloth and left to mellow, absorbing the oil and equalizing the heat throughout the mass.

The hides are then wiped of superfluous grease; laid across poles, flesh side out; dried, weighed, stamped, and marketed. The result is said to be excellent, no acid, alkali, fermentative, or other destructive application or process detracting from the weight or injuring the cohesion of the tissues.

Hun-ga'ri-an Ma-chine'. (*Hydraulic Engineering.*) The Chemnitz pressure engine. See AIR AS A WATER ELEVATOR, Fig. 58.

Hunt'er's Screw. A differential screw; named after its inventor, Dr. John Hunter. See DIFFERENTIAL SCREW.

Hunt'ing-cog. (*Gearing.*) A tooth in a cog-wheel which is *one* more than a number divisible by the number in the pinion with which it engages. If the pinion contains 8 leaves and the wheel 65 teeth, the 65th, or *hunting-cog*, prevents the recurrence of each leaf of the pinion with every 8th cog of the wheel, which would be the effect were the relative numbers 8 and 64. When the numbers are 8 and 65, the wheel will revolve 8 times and the pinion 65 times before the same leaves and teeth will be again engaged.

Hunt'ing-horn. (*Music.*) *a.* A bugle used in the chase.

b. A wind-instrument of metal, usually with a circular tube. See HORN, *k*.

Hunt'ing-watch. (*Horology.*) A watch with a metallic case over the crystal for its protection.

Hur'dle. 1. (*Husbandry.*) A rectangular frame of vertical stakes and interwoven withes of hazel, elm, oak, or other suitable saplings. Hurdles, about 6 feet long and 3 feet high, are used in husbandry in making temporary enclosures and fences, each section being secured by a ring to a driven stake.

Ornamental hurdles for screens, fences, etc., are made of iron, either cast or wrought. Each hurdle forms a panel, and is secured at its ends to stakes. Cast-iron hurdles consist of the marginal frame and an ornamental filling, according to the taste of the designer. Wrought-iron hurdles have a frame of bar-iron, and interlacing work of wire resembling network.

2. In *fortification*, hurdles are smaller, and are used as *revetments* in embrasures to strengthen the parapet. The *gabion* commonly used for this purpose is a *crate*, differing from a hurdle only in being cylindrical. See GABION.

A rectangular, flat structure made of stakes and withes, used in an emergency to stop breaches.

3. (*Hat-making.*) A grid of wood or wire, on which a bunch of felting hair is laid for *bowing*.

Hur'dle-nail. A tough flat-headed nail used in securing the parts of a hurdle together.

Hur'dy-gur'dy. (*Music.*) A stringed instrument having a lute-shaped body and neck. The strings are regulated on the latter by the fingers, and are vibrated by a revolving wheel.

Hurl. (*Hatting.*) The table on which the material for a hat-body or the fur for a nap is *bowed*.

Hur'ri-cane-deck. (*Shipbuilding.*) 1. The upper deck of an American river or lake steamboat above the cabins.

2. A raised platform on an ocean-going steam-vessel, extending from side to side, above deck amidships. A station for the officer in command.

Hur'ries. A *staith* or timber framing, on to which coal-cars are run, and from which they discharge their loads by means of spouts to the holds of the ships.

Hurst. The ring or collar of a trip-hammer helve on which are the trunnions on which it oscillates.

Hur'ter. 1. (*Fortification.*) *a.* A timber placed at the foot of the interior slope as a revetment, to prevent the injury of the parapet by the wheels of the gun.

b. (*Of a gun-carriage.*) Pieces of wood or iron at the front of the chassis to prevent the top carriage from running off when "in battery." The counter-hurter is a similar piece at the rear of the chassis for checking the recoil of the carriage.

2. (*Vehicles.*) A butting-piece on an axle. A strengthening piece placed against a shoulder of an axle.

Hus'band-ry. For list of machines, implements, and tools, see AGRICULTURAL IMPLEMENTS and HUSBANDRY, pp. 23–25.

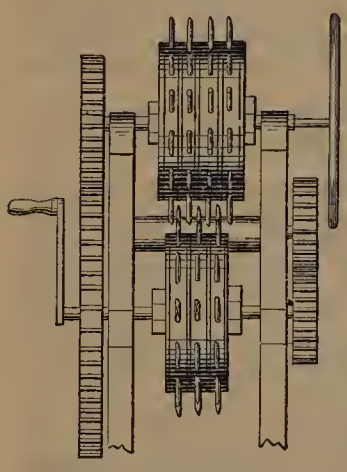
Hush'ing. (*Mining.*) *a.* A term applied to one mode of exposing and collecting ore. In a ravine where surface ore is exposed or but lightly covered, a body of water is dammed and then allowed to *flash* through the ravine, tearing up the earth and stones and exposing new surfaces, from whence the ore is gathered. The word is probably a corruption from *flushing*, which signifies a copious dash of water, as *flushing a sewer*. See FLUSHING.

b. A process of clearing water from the surface of ore, in stream works, by diverting and directing streams of water thereon.

Husk. (*Milling.*) The supporting frame of a run of millstones.

Husk'er. An implement or a machine for removing the shucks from ears of corn. See CORN-HUSKER.

Fig. 2610.



Husk-Hackler.

Husk-hack'ler. A machine for tearing corn-husks into shreds for stuffing for mattresses, pillows, cushions, etc.

Fig. 2610 shows a hackling-machine in which the toothed cylinders are driven at different rates of speed, whereby a splitting and combing action is obtained, as the husks are fed through.

Husk'ing-glove. A glove with claws or prongs, adapted to grasp the ear of corn and tear the husk therefrom. Some of these implements have also cutting jaws to sever the butt of the ear from the stalk.

Husk'ing-peg. A pin or claw worn upon the hand and used to assist in tearing open the shuck when husking ear corn. Ingenuity is apparently exhausted in contriving convenient rings and rests for the fingers, and mode of attaching to the hand.

Hut. The back end or body of the breech-pin of a musket.

Hutch. 1. (*Mining.*) *a.* A low-wheeled car adapted to run on a track in the gallery of a mine, to be lifted on the cage to the surface, and then run off to the dumping chute, by which its contents are carried to wagons.

b. A cistern or box for washing ores.

2. (*Milling.*) The case of a flour bolt. A *bolting-hutch*.

3. A kneading-trough.

Hutch'ing. (*Mining.*) A separation of ore in a sieve, which is suspended from a lever or held in the hands, and agitated in a vat of water. See JIGGER.

Huy-ghen'i-an Eye-piece. (*Optics.*) The *negative eye-piece*, named after its distinguished inventor, Christian Huyghens, a Dutch astronomer (1629–1695). This wonderful man excelled in mathematical and mechanical science and art. He improved the telescope; discovered the ring of Saturn (as such); reapplied the pendulum to beating time, and first accurately adapted it; invented the micrometer; and in his various communications to the Academy of Sciences in Paris and the Royal Society of London illuminated all he undertook.

He was one of the emigrants driven from France at the revocation of the Edict of Nantes, and exchanged the friendship of Louis XIV. for that of Newton. See NEGATIVE EYE-PIECE.

Hy-al'o-graph. An instrument for tracing a design on a transparent surface.

Hy-al'o-type. (*Photography.*) A photographic positive on glass.

Hy'drant. A valve and

Fig. 2611.

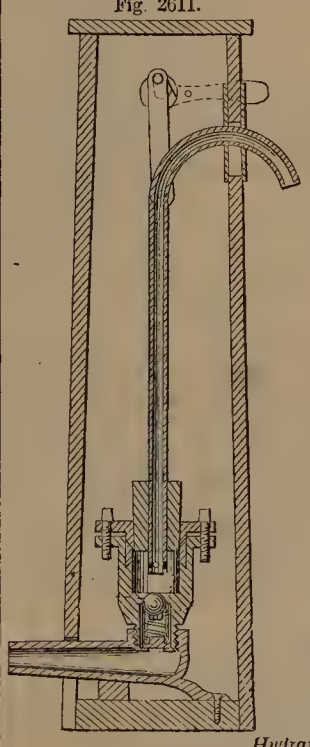
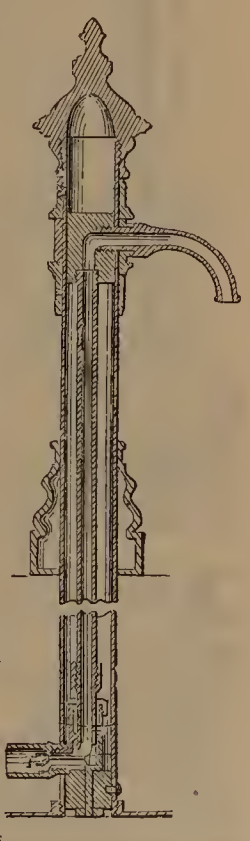


Fig. 2612.



Hydrants.

spout connecting with a water-main, and by which water may be drawn from the latter. In the domestic form, as usual in the yards of our city houses, the spout is elevated sufficiently to allow it to discharge into a tub or bucket, the valve being operated by a handle. Provision is also made for allowing the contents of the discharge-pipe to run back out of the way of frost. In the example, Fig. 2611, the depression of the goose-neck forces a piston into a chamber which empties itself through the discharge-pipe; the end of the pipe depresses a valve and allows the water to flow continuously from the main. The elevation of the goose-neck closes the valve, and the rising of the piston empties the discharge-pipe into the piston-chamber.

In Fig. 2612, the water is let on or off by rotating the tube, which opens or closes the foot-valve *I* by means of a stud on the tube. Near the lower end of the tube is a perforation which may be brought into coincidence with a wasteway when the valve is closed, and thus empty the stand-pipe.

A large kind of hydrant, having a larger service-pipe from the main, and used for connection of hose for street washing or in case of fire, is known as a *fire-plug*.

Hy'dra-pult. A garden syringe. A force-pump on a portable scale.

Hy-drau'lic Belt. An endless woolen band for raising water. The lower bight is immersed in water, and the upper bight passes over a roller. The belt travels about 1,000 feet per minute, and discharges at its upper turn.

Hy-drau'lic Block. (*Shipbuilding.*) An hydraulic lifting-press occupying the place of a *building-block* beneath the keel of a vessel in a repairing-dock. Being adjustable as to hight, it is useful for straightening a ship that has become *hogged* or *sagged*.

Fig. 2613.

Hydraulic Brush.

Hy-drau'lic Brush. One having a hose connection through its handle so as to discharge water upon the surface or object being scrubbed. The one shown, intended for washing windows, has vanes in the stock, and the force of the water causes the brush to revolve and the water to spray upon the window.

Hy-drau'lic Cane. This pump consists of a vertical pipe whose lower end has a valve opening upwardly and plunged in the water of the cistern or well. A rapid vertical reciprocation is given to the tube, and the water is caused to ascend therein; positively as the lower end plunges into the water raising the valve, and relatively as the water slips in the tube as the latter descends quickly. An air-chamber above makes the discharge continuous.

Hy-drau'lic Ce-ment'. A cement which possesses the property of hardening under water and resisting decomposition by that element. Various substances, mixed with sand, have been employed for this purpose, fulfilling more or less perfectly the required conditions.

Septaria are used where readily procurable.

The Romans used pozzuolana, volcanic ashes containing a considerable proportion of clay and oxide of iron. A similar product called *trass*, found in large quantities on the Lower Rhine, is used in Germany. For lining their reservoirs, the Romans employed pure lime and finely pounded brick.

The principal supply is, however, derived from various limestones which contain insoluble matters, as silica, alumina, magnesia, and oxide of iron, in varying proportions. These are burned, causing chemical changes and combinations in the constituents of the mass, which is then pulverized for use.

The so-called "Roman" cement, patented in England by Parker in 1796, is prepared from nodular concretions of limestone, usually containing veins of calc spar, found in beds of clay.

Portland cement, which ranks among the highest in point of tenacity and durability, is made from the deposits formed in the beds of some rivers which flow through chalk and clay formations, mixed with a proportion of carbonate of lime. These are incorporated under water, burned, and ground.

Several varieties of hydraulic cement are prepared in the United States, where it is also very generally known as "water lime." See CEMENT.

Hy-drau'lic Clock. An ancient form of time measurer. It was described by Ctesibus. One was presented by Haroun al Raschid to Charlemagne about A. D. 801. See CLEPSYDRA.

Hy-drau'lic Con-dens'er. (*Gas.*) The chamber into which gas from the retorts is conveyed by the dip-pipes to be cooled. See HYDRAULIC MAIN.

Hy-drau'lic Crane. (*Hoisting.*) An application of the hydraulic press to lifting. See HYDRAULIC ELEVATOR, HOIST, LIFT, etc.

Hy-drau'lic Dock. An apparatus (*J*, plate opposite page 1150) by which a vessel is raised clear of the water for examination and repairs. The vessel is brought over a platform which is slung between the frames, being suspended by the requisite number of chains, say 20 on each side, which pass over cast-iron pulleys supported on the top of the wooden framework. The lower ends of the chains are fixed to the platform, and the upper ends to a horizontal beam of wood, which is attached by means of a cross-head to the ram of an hydraulic engine. When the ram, therefore, which is placed in a horizontal position, is moved, by the injection of water into the cast-iron cylinder in which it works, the motion is communicated to the horizontal beam, and thence, by the suspending chains, to the platform bearing the vessel, which is thus slowly raised to the surface.

The longitudinal and the end view of the platform and vessel will explain the operation of the apparatus. In both of these views, *a* represents the platform; *b*, the suspending chains; *c*, the pulleys on which they run; *d*, the horizontal beam to which the chains are attached; *e*, the hydraulic engine; and *f*, the injection-pipe by which the water is forced into the ram.

The fixtures of the cylinder are embedded in a large mass of masonry, so as to render it quite immovable.

There are several racks attached to the apparatus, for supporting the platform, and taking part of the weight off the ram after the vessel is suspended. When she is ready to be lowered, these racks are unshipped, and the water being permitted to escape through a small aperture provided in the cylinder for that purpose, the vessel slowly descends into the water. The perpendicular *lift* of one of these docks in New York Harbor is ten feet.

Hy-drau'lic El'e-va'tor. (*Hoisting.*) A platform lift worked by hydraulic power.

A strong rectangular frame having a hydraulic press at each corner. These are operated by a larger

and a smaller pump. On the plungers of the pumps rest two additional frames, arranged to have a truly vertical motion. The machine is adapted for transferring railway-carriages from one line of track to another, and for this purpose is placed under the carriage, and the larger pump worked until the frames are brought to bear under the axles; the operation of the smaller pump then lifts the flanges of the wheels clear of the rails. When the carriage is transferred, the water is allowed to flow back from the pumps to the cistern, and the carriage lowered into place on the rails. See also Figs. *J*, plate opposite page 1150, and *L*, page 1157.

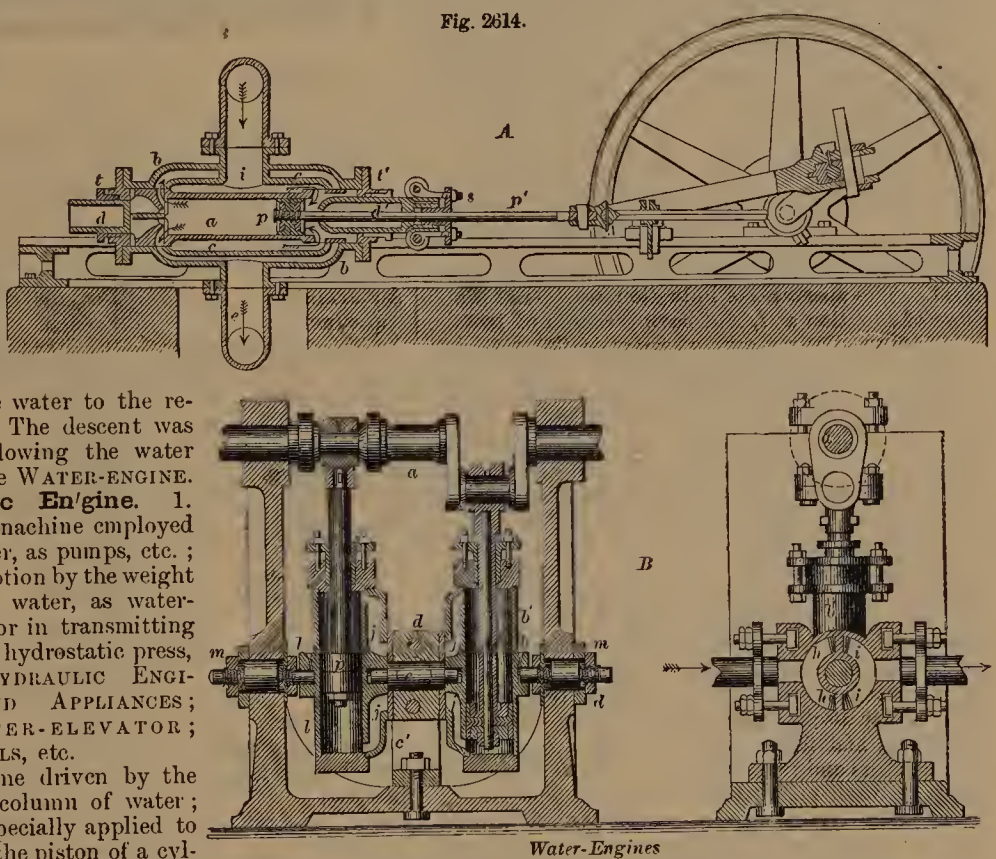
In 1812, Bramah patented a plan for laying water-mains in cities, the water to be under heavy pressure from force-pumps, and to be used for extinguishing fires and for operating hydraulic machines in factories, warehouses, etc., for elevating heavy weights, goods, etc.

The Ascenseur Edoux of Paris consists of a cylinder 66 feet long, sunken perpendicularly into the earth, with a plunger descending into it to the same depth, and packed water-tight at the top of the cylinder. Into this, below the packing, water is admitted by means of a valve. The piston rises under the pressure of the water to the required hight. The descent was effected by allowing the water to escape. See WATER-ENGINE.

Hy-drau'lic En'gine. 1. An engine or machine employed in raising water, as pumps, etc.; or receiving motion by the weight or impulse of water, as water-wheels, etc.; or in transmitting power, as the hydrostatic press, etc. See HYDRAULIC ENGINEERING AND APPLIANCES; PUMP; WATER-ELEVATOR; WATER-WHEELS, etc.

2. A machine driven by the pressure of a column of water; the term is especially applied to one in which the piston of a cylinder is driven by water-power.

Fig. 2614.



Water-Engines

The hydraulic engine of Huelgoat, in Brittany, is used to drain a mine; is single-acting, and acts directly to lift the piston of the pump. It makes five and a half strokes per minute, the stroke being a little more than eight feet in length. The piston-rod is 767 feet long, and it weighs 16 tons. The power of the engine is derived from a source at a hight 370 feet above its own level. See Delaunay's "Mechanics."

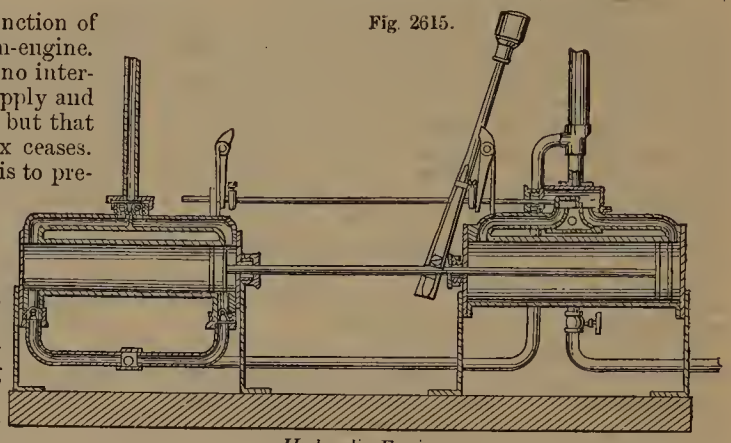
Perret's hydraulic engine *A* (French) has a cylinder and a double-acting piston. The motion is communicated to a working shaft in the ordinary way. The peculiarities consist in the manner of admitting and discharging the water. This is effected through openings at each end of the cylinder which occupy the greater part of its circumference and form a sort of annulus; there being left only enough solid metal to connect the end of the cylinder with the body. Thus the water is admitted to the interior from all sides. To facilitate this, the cylinder is entirely enveloped by a second cylinder, with a space intervening between the two, which is filled with the water of induction. The extreme portions of the working cylinder are turned very smooth externally in a lathe, and the ends of the enveloping cylinder are here contracted, and turned likewise on the inside, so as to make a joint as nearly as possible water-tight. Both these cylinders are enveloped completely by a third and larger one, between which and the second there is a space for the escape of the water on its discharge. This cylinder and the second are cast in a single piece, and form one body. The extremities of the third, like those of the second, are adapted accurately to the surface of the first, but there is a space between the second and third at this surface, which is as wide as the annular series of openings above described in the first, by which the water is to be admitted into or discharged from the first, which is the working cylinder. The inner cylinder moves backward and forward alternately, so as to present the openings which answer to its valves in front of the spaces which communicate with the supply and exhaust.

The motion of the working cylinder through the small space which is required to effect the admission and discharge of the water is accomplished by means of an eccentric upon the crank shaft, which is set at right angles to the crank, and 90° behind it in the direction of revolution; so that the motion of the cylinder is in a direction contrary to that of the piston in the first half, and in the same direction in the last half, of the stroke. The breadth of the annular opening is exactly equal to that of the metal which separates the supply from the exhaust in the exterior cylinders; and it will be seen that the

working cylinder itself performs the function of the slider in the valve-box of the steam-engine. It happens accordingly that there is no interval between the shutting off of the supply and the commencement of the discharge; but that the efflux begins the moment the influx ceases. The main object of the specific devices is to prevent jar.

a is the inner cylinder.
b the external cylinder.
c the intermediate cylinder.
p is the piston beginning to advance.
i is the induction, *e* the eduction pipe.
d d' are prolongations of the working-cylinder, of smaller diameter, sliding back and forth in stuffing-boxes *t t'*.
p' is the piston-rod working in a stuffing-box *s*.

Fig. 2615.



Hydraulic Engine.

In Coque's water-engine a small quantity of air is admitted along with the water, to absorb hydraulic concussion.

Ramsbottom's hydraulic engine *B* (English) is oscillating, and employs two cylinders *b' l*, operating one crank-shaft *a*, by means of two cranks at right angles to each other. In one of the accompanying figures the channels of induction are marked *j*, and are cast with the cylinders; the dotted circle *c* shows the position of the supply and discharge pipes; in the other figure these pipes are indicated by arrows. The two views are vertical cross-sections at right angles to each other, one being through the axes of the cylinders and the other through the middle post in which the inner trunnions of the cylinders are journaled. The apertures of induction are seen at *h* and those of eduction at *i*, and have the form of truncated circular sectors, whose center is the center of motion. The induction and eduction spaces are divided by a sectoral partition; the apertures of admission and discharge on the sides of the cylinders are of similar construction. The surfaces of contact between the cylinders *b' l* and the support *d* are plane and polished, and are made water-tight by the adjusting screws *m m* of the pivots. When the piston *p* is at the end of its course in either direction the cylinder and crank are vertical, and the valves all momentarily closed, the openings by which the channels *j j* communicate with the discharge and supply pipes presenting themselves exactly opposite the solid sectors which separate *h* from *i*. In the next moment the flow of water will recommence, the cylinder discharging itself from the full side of the piston, and filling anew from the opposite side. Air-chambers and relief-valves are used as a provision against counter-pressure and hydraulic shocks.

The Ramsbottom engine is largely used in England for operating printing-presses, circular saws, lathes, cranes, etc. In default of a natural head of sufficient power, the head is established in an *accumulator* of power, which is a body of water driven into a reservoir under heavy pressure, by forcing pumps worked by steam. For lighter industries such expedients are unnecessary. In cities in which the water distribution is from elevated reservoirs, and in which the water-supply is sufficiently abundant to justify the application of a portion of it to industrial uses, the water-engine is recommended by the combined advantages of simplicity, neatness, compactness, constant readiness for work, perfect safety, economy while working, and the absolute cessation of expenditure during interruptions and after the work of the day is over.

Fig. 2614 is a form of water-engine in which the water from an elevated reservoir bears upon the pistons of the pump and engine and operates the pump. The slide-valves of the engine and pump are actuated by a lever on the common piston-rod, which is tilted by striking the stuffing-box.

Hy-drau'lic En'gi-neer'ing and De-vi'ces.

Absorbing-well.
Accumulator.
Aft-gate.
Air-lock.
Ajutage.
Alarm-funnel.
Alcaraza.
Anti-guggler.
Apron.
Aquarium.
Aqueduct.
Archimedean screw.
Armor. Submarine
Artesian well.
Ash-leach.
Back.
Back-cutting.
Backwater.
Bag and spoon.
Balance-bar.
Balance-gate.
Ballast-engine.
Ballast-heaver.
Bank-protector.
Barker's mill.
Barrack.
Barrel-filler.
Barrel-filling gage.
Barrel-washer.
Bascule.
Basin.
Batardeau.
Bath.
Bath-heater.
Bath-tub.
Bay.
Bearing-pile.
Beck.
Beer-cooler.
Beer-engine.
Beer-float.
Beer-fountain.
Beer-tap.
Bilge-water alarm.
Bilge-water discharge.
Blast-hole.
Blower. Hydraulic
Boiler-prover.
Bollard.
Bond-rail.
Bonnet.
Boom.
Border-pile.
Bottle-boot.
Bottle-faucet.
Bottle-siphon.
Bottle-stopper.
Bottle-washer.
Bottling-machine.
Bowlder-head.
Branch.
Breakwater.
Breakwater-glacis.
Breasting.
Bridge.
Bubbles.
Bucket.
Bucket-engine.
Bucket-wheel.
Bung.
Burette.
Burrock.
Bye-wash.
Caisson.
Camel.
Camp-sheeting.
Canal.
Canal-lift.
Canal-lock.
Canal-lock gate.
Cane. Hydraulic
Cap.
Catch-basin.
Catch-feeder.
Catch-water drain.
Catch-work.
Cauf.
Centrifugal filter.
Centrifugal pump.
Cesspipe.
Cesspool.
Chain-pump.
Chain-towing.
Chamber-closet.
Chapelet.
Check.
Chute.
Cistern.
Clap-sill.
Cleansing-vat.

Clepsydra.
Clough.
Clow.
Coal-breaking jack.
Coal-washer.
Cock.
Coffer.
Coffer-dam.
Coffin.
Colluviarium.
Condenser.
Conduit.
Cooler.
Cooling-floor.
Corbel-piece.
Corking-machine.
Cork-jacket.
Cork-press.
Cork-puller.
Corkscrew.
Counter-drain.
Cradle.
Crane. Hydraulic
Crank-prover.
Crank-puller.
Crawl.
Crevasses. Stopping
Crib.
Croy.
Cruive.
Cumming.
Curb.
Current-fender.
Current-gage.
Current-meter.
Current-regulator.
Current-wheel.
Cut-off.
Cutwater.
Dam.
Danaide.
Dead-well.
Defecator.
Digue.
Dike.
Dip.
Distributing-reservoir.
Diversion-cut.
Diving-apparatus.
Diving-bell.
Dock.
Dolphin.
Draft-box.
Drag.
Drain.
Draining-apparatus.
Draining-auger.
Draining-engine.
Draining-plow.
Draining-pump.
Drain-trap.
Draw-gate.
Dredge.
Dredge-boat.
Dredging-machine.
Drill for well-boring.
Driven well-tube.
Dropping-tube.
Drove.
Drowning-bridle.
Drum-wheel.
Dry-dock.
Dutch-scoop.
Edulcorator.
Ejector.
Emissarium.
Enrockment.
Explorer.
Extinguisher.
Facing.
Fascine.
Faucet.
Feeder.
Feed-head.
Fender.
Fender-pile.
Fermenting-vat.
Filter.
Filter-bed.
Fire-cock.
Fire-engine.
Fire-extinguisher.
Fire-plug.
Fish-garth.
Fish-way.
Flashing.
Flews.
Float.
Float-case.
Floater.
Floating-clough.
Floating-dam.
Floating-dock.
Floating-harbor.
Floating-safe.
Flood-flanking.
Flood-gate.
Flume.
Flushing.
Footing.
Forebay.
Foreland.
Foreshore.
Fountain.
Fountain. Beer
Fountain of Hero.
Fountain-inkstand.
Fountain-lamp.
Fountain-pen.
Fountain. Portable
Frith.
Funnel.
Fyke.
Gabion.
Gage-rod.
Garth.
Gate-chamber.
Goose-neck.
Go-out.
Graving-dock.
Gridiron.
Grillage.
Groin.
Grouting.
Guide-lock.
Guide-pile.
Guard-pile.
Gutter.
Gyle.
Hand-swipe.
Hard.
Hatch.
Head.
Head-bay.
Head-gate.
Heck.
Hedgehog.
Hollow quoin.
Horn-drum.
Horse-path.
Hose.
Hose-bridge.
Hose-coupling.
Hose-shield.
Hydrant.
Hydrant-valve.
Hydraulic belt.
Hydraulic block.
Hydraulic buffer.
Hydraulic cane.
Hydraulic cement.
Hydraulic clock.
Hydraulic crane.
Hydraulic dock.
Hydraulic elevator.
Hydraulic engine.
Hydraulic governor.
Hydraulic hoist.
Hydraulic indicator.
Hydraulic jack.
Hydraulic lift.
Hydraulic lifting-jack.
Hydraulic main.
Hydraulic motor.
Hydraulic nozzle.
Hydraulicon.
Hydraulic pivot.
Hydraulic pressure-pump.
Hydraulic propeller.
Hydraulic punch.
Hydraulic ram.
Hydraulic shears.
Hydraulic slip.
Hydraulic telegraph.
Hydraulic valve.
Hydro-electric machine.
Hydro-extractor.
Hydrometer.
Hydrometric pendulum.
Hydrometrograph.
Hydrophore.
Hydroscope.
Hydrostat.
Hydrostatic balance.
Hydrostatic bellows.
Hydrostatic engine.
Hydrostatic jack.
Hydrostatic lamp.
Hydrostatic press.
Ice-apron.
Ice-breaker.
Impluvium.
Inclined plane.
Invert.
Jette.
Jetty.
Keel-fat.
Keir.
Kemelin.
Kid.
Kiddle.
Ladle-board.
Land-tie.
Land-tank.
Launder.
Leach.
Leaf.
Leak-alarm.
Leam.
Leat.
Levee.
Level.
Life-preserver.
Lift. Canal
Lift. Lock
Lift. Wall
Lighter.
Lighthouse.
Lining.
Liquid-cooler.
Liquid-gage.
Liquid-meter.
Litrameter.
Lock. Canal
Lock-chamber.
Lock-gate.
Lock-paddle.
Lock-sill.
Lock-weir.
Lode.
Main.
Mantle.
Marigraph.
Marine-alarm.
Marine-railway.
Mash-cooler.
Mash-tun.
Measuring-apparatus.
Measuring-faucet.
Measuring-funnel.
Measuring-pump.
Meter.
Mill-dam.
Mineral-water apparatus.
Miser.
Miter-drain.
Miter-post.
Miter-sill.
Mole.
Monte-jus.
Morton's slip.
Mud-boat.
Mud-drag.
Nautical-alarm.
Nautilus.
Needle.
Negative-well.
Noria.
Nozzle.
Oar.
Oenometer.
Oil-feeder.
Ombrometer.
Organ. Hydraulic
Outburst-bank.
Outfall.
Overflow-basin.
Paddle.
Paddle-wheel.
Pannier.
Penchute.
Penstock.
Percolater.
Perpendicular lift.
Peruvian wheel.
Picotah.
Pier.
Pierre-perdue.
Pile.
Pile-driver.
Pile-saw.
Pipe.
Pipette.
Pipe-prover.
Pitched work.
Pitot's tube.

Platform.
Plug. Fire
Pneumatic pile.
Point.
Pond.
Pot-wheel.
Pound.
Pozzuolana.
Pressure-pump.
Propeller.
Psychrometer.
Puddle.
Puddling.
Puffer.
Pugging.
Pull-cock.
Pulp-washer.
Pump.
Pumping-engine.
Punching-bear.
Quay.
Race.
Rail-bender.
Rail-punch.
Rain-gage.
Raising sunken vessels.
Ram. Hydraulic
Reach.
Reservoir.
Rheometer.
Riddle.
Rinsing-machine.
Rip-rap.
Rising-main.
River-wall.
Root.
Round.
Salmon-ladder.
Salmon-stair.
Sand-trap.
Sand-washer.
Sasse.
Saucer.
Scoop.
Scoop-wheel.
Scouring-basin.
Screw. Archimedean
Screw-dock.
Screw-pile.
Scroll.
Sea-gates.
Sea-wall.
Sectional dock.
Separating-weir.
Sett.
Sewer.
Shaft-straightener.
Sheeting-pile.
Shingle-trap.
Ship-jack.
Shoal-alarm.
Shoe.
Shrouding.
Shuttle.
Side-pond.
Sink.
Sink-trap.
Siphon.
Siphon-bottle.
Sirup-stand.
Slack-water navigation.
Slide.
Slip.
Slop-hopper.
Sludging.
Sluice.
Sluice-gate.
Sluice-valve.
Snag-boat.
Soda-fountain.
Sough.
Souterazici.
Spile.
Spout.
Spreader.
Spring-tester.
Spur.
Stade.
Stage.
Staith.
Stanch.
Stand-pipe.
Starling.
Start.
Stay-pile.
Steam fire-engine.
Steam-fountain.
Steam stench-trap.
Sterhydraulic apparatus.
Still.
Stockade.
Stop-cock.
Stop-plank.
Stop-valve.
Storm-pavement.
Street-sprinkling cart.
Street-washer.
Street-watering.
Submarine apparatus.
Submarine armor.
Submarine boat.
Submarine cable.
Submarine excavator.
Submarine lamp.
Submarine telescope.
Submarine valve.
Submarine vessel.
Sump.
Swash-bank.
Sweetening-cock.
Swing-bridge.
Syringe.
Tachometer.
Tail-bay.
Tail-gate.
Tail-race.
Tank. Oil, etc.
Tan-pit.
Tap.
Tapping water-pipe.
Testing-machine.
Thatch wood-work.
Tidal basin.
Tide-alarm.
Tide-gage.
Tide-gate.
Tide-lock.
Tide-mill.
Tide-motor.
Tide-power.
Tide-valve.
Tide-wheel.
Towing.
Trap.
Traversing-jack.
Trough.
Trunk.
Tub.
Tube.
Tube-clamp.
Tube-well.
Tun.
Tunnel.
Turbine.
Tympanum.
Urinal.
Valve.
Vase.
Velinche.
Vent.
Vineficateur.
Wagon-tipper.
Wale.
Warp.
Waste.
Waste-trap.
Waste-weir.
Water-balance.
Water-barrow.
Water-bearing.
Water-bellows.
Water-carrier.
Water-clock.
Water-closet.
Water-cooler.
Water-crane.
Water-engine.
Water-elevator.
Water-frame.
Water-gage.
Water-gas.
Water-gate.
Water-gilding.
Water-glass.
Water-indicator.
Watering-cart.
Water-leg.
Water-level.
Water-line.
Water-lute.
Water-mark.
Water-meter.
Water-mill.
Water-motor.
Water-pillar.
Water-pressure engine.
Water-proofing.
Water-room.
Water-screw.
Water-snail.
Water-supply for locomotives.
Water-twist.
Water-way
Water-wheel.
Water-works.
Wave-power.
Wave-trap.
Way-gate.
Weel.
Weir.
Weir-table.
Well.
Well-boring.
Wet-dock.
Wharf.
Wheel-jack.
Wheel-press.
Wince.
Woltmann's mill.
Worm.
Worm-safe.
Wort-cooler.
Zigzag.

Hy-drau'lic Gov'ern-or. (*Steam.*) Another name for Smeaton's *cataract.* See CATARACT; CORNISH-ENGINE.

Hy-drau'lic Hoist. (*Hoisting.*) One device for this purpose consists of a large cylinder in which the slow and forcible movement of a piston is made to drive water into a smaller cylinder and impart a relatively larger stroke to a piston therein. It is the converse of the hydrostatic press. See ACCUMULATOR, Fig. 24; Figs. *C J*, opposite page 1150; *K L M*, page 1157.

Hy-drau'lic In'di-ca'tor. A gage (*B*, plate opposite page 1150) to indicate hydraulic pressure. Water under the pressure to be tested is admitted through the pipe *a* to a cylinder enclosing a piston which tends to depress the short arm of the lever *b*, counterbalanced by the weight *c*; a movable weight slides on the long arm of the lever, and weights *d* are added to its outer end when a very great pressure is to be measured.

Hy-drau'lic Lift. (*Hoisting.*) An apparatus (*K*, page 1157), on the principle of the hydraulic press, is enclosed within the casing *a*, and is by means of a lever *h* caused to draw upon the chain *e*, which passes over two sets of pulleys, in the example twelve in number, and is thence conducted by leading pulleys over the jib *d*. The weight *c* is by this arrangement raised twelve times the stroke of the ram at each movement of the latter. There is, of course, a corresponding loss of power, but this is of less moment than the increased speed attained.

Hy-drau'lic Lift'ing-jack. (*Hoisting.*) A portable lifting apparatus in which the power is a form of the hydrostatic press (*M*, in same plate). In this form of the machine, the reservoir *a*, pump

b, and pressure cylinder *c* are above the ram *d*, and maintained in line therewith by the tubular casing *e*. The plunger *f* is operated by the lever *g*. Water is admitted to the reservoir *a* through the screw-fitted opening *h*, and flows through the valve *i* into the pump-cylinder *b*, when the piston *f* is raised. The downward motion of the piston forces the water through a suitably arranged valve into the lower cylinder *c*, where the pressure it exerts between the head of the immovable ram and the movable pump and reservoir causes them to raise a weight placed either on the head *k* or projecting foot *l*. The machine is re-adjusted for lifting by the screw-valve *m*, which opens a communication between the upper and lower chambers.

M' and *M''* are perspective views of a similar machine.

M''' has a hollow base and a stationary ram which acts as a guide-post. The cylinder with a protruding claw slides upon the ram.

Hy-drau'lic Lime. A kind of lime which has the capacity for hardening under water. See HYDRAULIC CEMENT.

Hy-drau'lic Main. (*Gas.*) A strong, cast-iron pipe, usually about 12 inches in diameter, and of a length sufficient to receive all the perpendicular pipes that convey to it the gas generated in the several retorts. The main is horizontal, and is supported on the brick-work that covers the ovens.

The hydraulic main contains a certain quantity of water, and the mouth of each gas-tube is submerged in the water, so that the gas flows through water and parts with a portion of its ammonia at this stage of the process. See DIP-PIPE; GAS-REGULATOR.

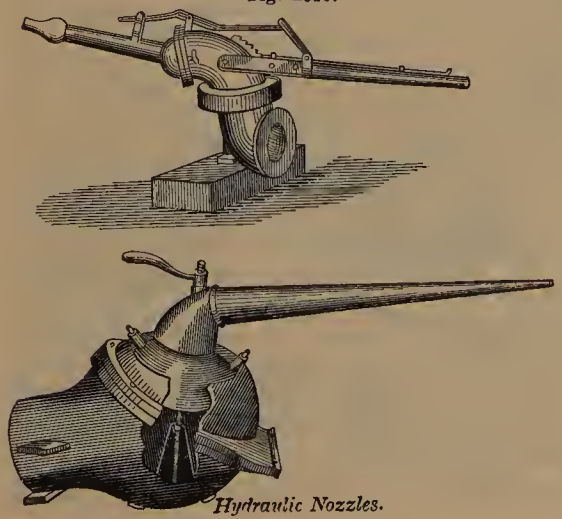
Hy-drau'lic Min'ing. (*Mining.*) A system of mining in which the force of a jet of water is used to wear down a bed of auriferous gravel or earth, which is passed through sluices to detain the particles of gold. See FLUME; HYDRAULIC NOZZLE.

Hy-drau'lic Mor'tar. Mortar in which the presence of alumina enables it to harden under water; producing an insoluble silicate of alumina. (See CEMENT.) It usually contains burned clay along with the more abundant lime, and sometimes oxide of iron. See HYDRAULIC CEMENT; POZZUOLANA.

Hy-drau'lic Mo'tor. A water-engine.

1. A hydraulic ram having connections which raise a piston that is forced down by atmospheric pressure at each cessation of the downward flow of water. By suitably arranged valves the water may be admitted alternately above and below the piston,

Fig. 2616.



Hydraulic Nozzles.

causing a reciprocating action similar to that of the steam-engine.

2. A machine in which a piston is moved in a cylinder by water from a head or stand pipe, in the manner of a steam-engine. Some engines on the Continent of Europe work with a head of 200 feet conducted by a pipe. See HYDRAULIC ENGINE.

Hy-drau'lic Noz'zle. (*Mining.*) A device for directing a stream of water upon a bank of auriferous dirt to crumble it down, that it may be passed through a sluice to collect the gold.

The nozzle has universal motion so as to direct the stream in any direction, in one case by two elbows and pairs of rings which slip on each other, and in the other case by a spherical segment and socket. These machines are made to collect the water of a number of hose-pipes into one stream which may be directed in one jet of from 4 to 7 inches in diameter upon a bank at a distance of 200 feet, if necessary to stand at that distance to avoid caving.

Hy-drau'li-con. (*Music.*) A water-organ. This form was known to the Alexandrian Greeks in the time of Hero, 150 B. C. It is supposed that air was forced by means of water. If so, it was rather a *water-bellows*. See ORGAN.

Hy-drau'lic Piv'ot. (*Machinery.*) A contrivance of Girard by which a film or body of water is introduced below the end of a vertical axis to bear the weight thereof, and prevent the actual friction of the axis on its step.

The hydraulic pivot, or liquid bearing, for stepping vertical shafts, is described in Bramah's planing-machine, English patent, 1802. See JOURNAL-BEARING; PALIER-GLISSANT.

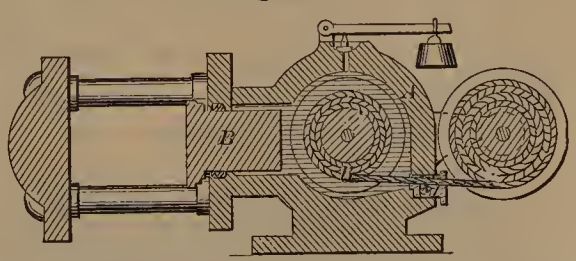
Hy-drau'lic Plat'form-lift. (*Hoisting.*) A form of hoisting-apparatus (*L*, page 1157) in which the small pump *a*, operated by the lever *b*, is caused to force water into the larger cylinder *c*, which contains a piston bearing the upright stem *d*, upon the upper end of which the platform *e e*, sliding upon appropriate guides, is fixed.

Hy-drau'lic Press. Another name for the *hydrostatic press*. *H*, plate opposite page 1150, represents a press for the extraction of liquids from the more solid saturated materials; such as the juices from the woody fiber of herbs in obtaining vegetable extracts.

In this, a horizontal plunger *a*, actuated by a screw *b*, works in a water-chamber *c d* to raise a ram *e*. A vertical screw *f* works in the head *g* on the standards, for raising or depressing the piston, between which and the ram *e* substances are compressed. When the juices of fruits, etc., are to be expressed, the platen is surrounded by a perforated box *j j*. See HYDROSTATIC PRESS.

Another form is that in which a cord or rope is drawn into the box to expand the liquid against the

Fig. 2617.



Hydraulic Press.

sides of the chamber, and thus press outwardly the ram. See STERHYDRAULIC PRESS.

Hy-drau'lic Pro-pel'ler. A mode of propelling vessels by the ejection of a body of water sternward.

It was invented by Dr. John Allen, and described by him in 1730. See his "Specimina Ichnographica." His method was to form a tunnel or pipe, open at the stern of the vessel, and by means of a pump to force water or air through it into the sea. The reaction thus occasioned would drive the ship forward. The design was put into execution upon a canal, with a boat of considerable size, and worked by pumps by manual labor, but he suggested the employment of a steam-engine, and its application to a vessel of 1,500 tons.

The hydraulic propeller of Dr. Allen formed the subject of a patent to David Ramsey, in England, 1788; and Rumsey, of America, 1782. The latter ran a vessel of 50 feet long on the Potomac, and one built on his plan was launched and fitted after his death, and ran on the Thames four miles an hour against wind and tide.

Dr. Franklin planned a boat of this kind in 1785, and it has since been tried on the Scheldt, two turbines being used for pumps.

Linnaker's hydraulic propeller, 1808, had pumps placed horizontally beneath the bottom of the vessel. The pistons were attached to hanging levers which were oscillated by the power of the steam-engine. The pistons reciprocated in longitudinal trunks parallel to the keel.

In a second plan, the pumps were vertical and discharged the water through horizontal trunks.

The "Nautilus," furnished with Ruthven's propeller, had a trial trip on the Thames in the summer of 1868, running in company with paddle-wheel steamers of the class that ply like aquatic omnibuses up and down the river. She ran at the rate of 13.5 and 7.2 miles per hour, with and against the tide, respectively, or at an average speed of 10.35 miles per hour. She then steamed down the river, and when off the Tunnel pier, with both strong wind and tide in her favor, going at full speed, was made, by reversing the valves, to stop dead in less than ten seconds and in about a quarter of her length. Her Majesty's iron-clad gunboat "Waterwitch" was fitted with the new propeller. The water is discharged in a heavy stream on both sides of the vessel, and its direction is under such command that the vessel is independent of her rudder, and is worked under the complete control of the master, officer of the watch, or man on deck, without any communication with the engine. The plan has been tried in the United States without commending itself as against the paddle and screw. Different modes of the application of the hydraulic propeller have been suggested for canal navigation.

Hy-drau'lic Pull'ing-jack. (*Hoisting.*) An application of the hydrostatic press.

A cylinder *a* (*C*, plate on the opposite page) contains a tube *b*, to which the piston *c* is attached. *d* is a smaller tube sliding within the piston and tube *b*. A valve *c* closes the communication between the cistern *f*, which contains a pump *f'* operated by the hand-lever *h*, and the cylinder *a*; two passages *g g* afford communication between the tube *d* and cylinder *a* at the back of the piston *c*. Water is poured into the cistern through an opening closed by a screw, and the jack suspended cistern end downward. Working the hand-lever *h* forces, by means of the plunger *h*, water through the tube *d* and passages *i i*, and depresses the piston to the bottom of the cylinder *a*. The water at the back of the piston returns at the same time to the cistern through the passages *g g*. By unscrewing the stop-valve *e*, the water returns through the tube *d* and passages *i i* to the cistern, relieving the piston from pressure and allowing a suspended weight to fall.

Hy-drau'lic Punch. An application of the hydrostatic press, comprising a force-pump and operating cylinder (*G*, same plate), in which the piston, carrying the punch *b*, is inserted, inclosed in a case *a*. The lever *c* operates the pump to depress the piston, and force the punch through a plate beneath; it is then raised by the lever *d* to punch another hole. A PUNCHING-BEAR (which see).

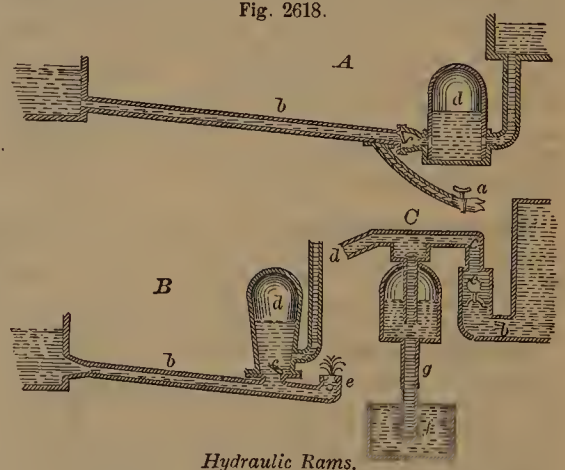
Hy-drau'lic Rail-bend'er. An implement for bending or straightening rails by hydraulic pressure (*E*, same plate). The action of the lever *a* operates a small force-pump within the casing, which is connected with a larger cylinder, the piston of which forces the plunger *d* against the rail midway between the points where it is held by the lips *c c*. Known as a JIM-CROW (which see).

Hy-drau'lic Ram. A device by which the fall of a column of water in a tube is caused to elevate a portion of itself to a hight greater than that of its source.

This depends on the well-known law of mechanical force, that the effect produced by a body is as its weight multiplied into the velocity, its absolute force constituting the momentum.

This principle was first practically applied in the construction of the water-ram by Mr. Whitehurst of Derby, England, in 1772. Whitehurst's ram is

Fig. 2618.



Hydraulic Rams.

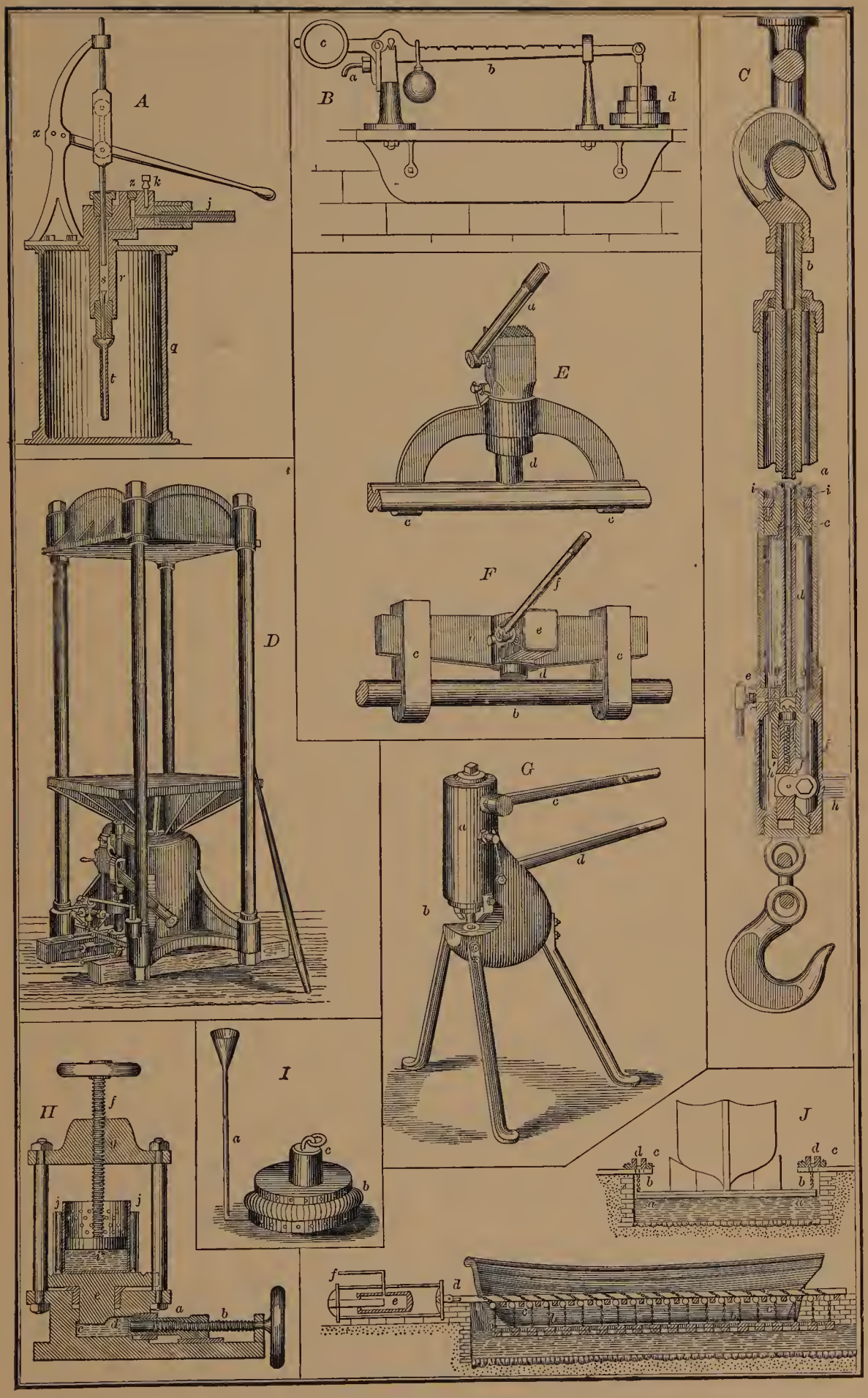
shown in *A*, Fig. 2618. It was not automatic, but depended upon the opening and shutting of a cock from which water for domestic purposes was drawn.

The operation is as follows: on opening the cock *a*, water from the cistern flowed down the pipe *b*, and on closing the cock, the sudden stoppage of the water caused the valve *c* to open, and a part to be forced through into the air-chamber *d*; the momentum imparted to the water would be sufficient to carry it to a hight as much greater than that of the descending column as the quantity of water in the former was less than in the latter; being, however, forced into the air-chamber, this effect was exerted intermediately through the compression of the air, rendering it more constant.

In 1796, Montgolfier, one of the inventors of the balloon, invented the self-acting ram, for which he obtained a gold medal at the French Exposition of 1802. This is absolutely automatic, maintaining its action regularly so long as the machine remains intact or the supply of water holds out.

A simple form is represented at *B*. This machine differed from that of Whitehurst merely in the addition of a waste-valve *c*; but this altered its entire character, and rendered it practically efficient as a water-raising machine.

The water, as before, flows down the pipe *b*, but the momentum thus acquired causes it to raise the



HYDROSTATIC PRESSES.

PLATE XXV.

See page 1150.

valve *e*, shutting off the water as before and causing it to spend its energy in forcing a portion of itself into the chamber *d*; but this done the valve drops, causing a flow through the pipe until the water has gained energy to again raise the valve, when the same series of events is repeated.

C represents the suction-ram; in this the water flows from the reservoir along the pipe *b c d*, having a ball-valve *e*; the water flowing from the reservoir through the pipe finally lifts the valve sufficiently to close the aperture *c*, stopping the flow while the pipe is discharged through *d* and creating a vacuum therein; the atmospheric pressure on the water in *f* now causes it to rise through the pipe *g* and be discharged by *d*. The ball-valve then drops by its gravitation to be again elevated by the current through the pipe, and the series of operations is continued.

The water-ram is only efficacious where there is a larger supply of water at command than is necessary to be raised, but in certain cases its power and constant and unfailing action render it very valuable.

Hy-drau'lic Shaft-straight'en-er. An hydraulic implement for straightening metallic bars and shafts (*F*, plate opposite page 1150). The beam *a* and shaft *b* are each inserted within the collars *c c*, and pressure applied through the plunger *d*, operated by a small hydraulic press enclosed within the casing *e* and worked by the lever *f*.

Hy-drau'lic Shears. A machine for shearing metals, etc., by the force of water-pressure (*O*, page 1157). The cutting-blade *a* is forced toward and drawn away from the stationary blade *b* by its attachment to the piston of a cylinder connected with a force-pump contained within the casing *c* and operated by a lever *d*.

Hy-drau'lic Slip. A slip-dock in which the cradle and its load, the ship, are hauled up the rails or ways, for the purpose of cleaning or repair, by the power of an hydraulic press. See SLIP-DOCK.

The cylinder of the press lies on a strong foundation at the upper end of the slip-way; its plunger has a *cross-head* connected by means of side-rods with a *cross-tail*, to which is attached the chain for hauling up the cradle. The chain consists of a series of long, straight links, or traction rods, each equal in length to the stroke of the plunger and connected together by pins. The plunger is driven by water, forced in by a set of pumps worked by a steam-engine. After a forward stroke of the plunger has been completed, an escape-valve is opened for the water, and the plunger is drawn back by a counterpoise; one length of traction rod is disconnected and taken out; and when the plunger has completed its return stroke, the shortened chain of traction rods is again connected with the cross-tail, to be ready for the next forward stroke, and so on. The operation of disconnecting the traction rods, taking out a length and reconnecting them, is called *fleeting*. The usual speed with large ships, including stoppages for *fleeting*, is about 4 feet per minute.

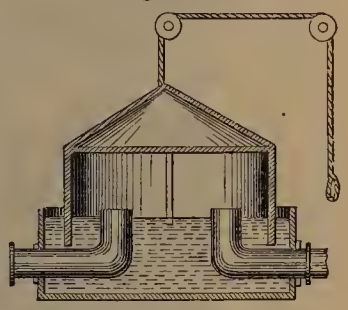
Hy-drau'lic Spring-test'er. An application of the hydrostatic press to testing the strength of springs (*P P'*, page 1157). *a* is a side view and *b* the plan of this device. It has an accumulator, into which air is forced by means of a hand-pump until the pressure is about 100 pounds per square inch. Power-pumps working in a cistern are then set in motion, pumping water into the cylinder until a pressure of about 300 pounds per inch is attained; by opening a stop-valve, this accumulated pressure is at once allowed to act on the ram and compress the spring to be tested. The ram is retracted by counterbalance weights when the pressure is removed.

Hy-drau'lic Tel'e-graph. A mode of communication by means of a column of liquid in a pipe, which is caused to move so as to actuate a hand, or by different levels to indicate messages or letters on a graduated or written scale against the fluctuating column. The plan was tried in France by Bossuet over a century since, with a pipe about three miles long.

Vallance's hydraulic telegraph was described by the inventor in a pamphlet in 1825.

Hy-drau'lic Valve. (*Pneumatics.*) An inverted cup which is lowered over the upturned open end of a pipe, the edge of the cup being submerged in water and closing the pipe against the passage of air.

Fig. 2619.



Hydraulic Valve.

The hydraulic valve of the gas-works governs the communication between the gas-holder and the main. When the valve is raised the communication is free between the two pipes; but when the valve is depressed the division plate descends into the water and closes the connection.

Hy-drau'lic Wheel. One for raising water by applied power, as the NORIA, SCOOP-WHEEL, TYMPANUM, etc. (which see). The wheel shown in the example is driven by steam or wind power, having buckets on its internal perimeter which raise water from the stream and discharge it right and left into the branches of the elevated gutter. It is intended for irrigating cotton, coffee, indigo, rice, and sugar lands, and for other purposes. See Fig. 2620.

Hy'dro-ba-rom'e-ter. An instrument for determining the depth of sea-water by its pressure.

In the United States Coast Survey Report, 1857, pp. 398 – 403, is an account of the sounding-apparatus of Lieutenant E. B. Hunt: "Arrange a weighted india-rubber air-vessel for dragging on the bottom; connect this with a boat or surveying-vessel by an air-tight tube of small bore; let this tube open in a cistern of mercury made air-tight; and from this cistern arrange a vertical glass column, open at the top, through which the mercury can rise to any hight required by the pressure due to the depth."

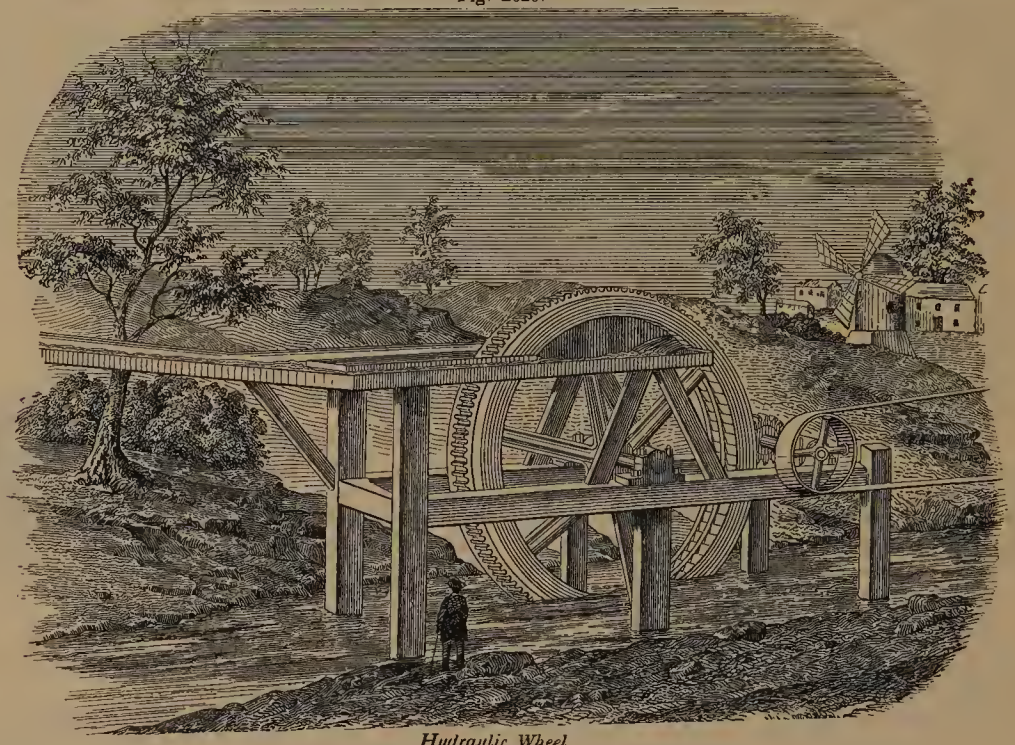
See also Ericsson's patent, September 22, 1863. Also McCord's, September 20, 1859, in which latter the pressure of the water pushes up a piston into a graduated cylinder, where the acquired elevation is registered.

Hy'dro-car'bon-burn'er. One in which liquid fuel is used beneath a steam-boiler, cooking-vessel, or otherwise. It usually has a jet of air or steam, frequently both, which carry with them a quantity of petroleum or coal oil in the form of spray which is ignited and burns below the boiler. Ingenuity is exercised in so arranging the burners that the jets in sufficient number are so disposed as to apply the flame to the surfaces of the boiler.

In Fig. 2621, the pipe *B* is a receptacle in which the oil is mixed with air, and the gases evolved. A small stream of oil enters by the pipe *i*, a current of air by opening *r*, and a jet of steam from the boiler by pipe *S*. Pipe *B*, containing steam, air, and gas, passes through the furnace, and on its return empties its heated contents in the midst of the fire.

In heating or cooking stoves, the burner may consist of a vaporizer in which a jet heats a small retort from which the coal oil issues in a vapor; or

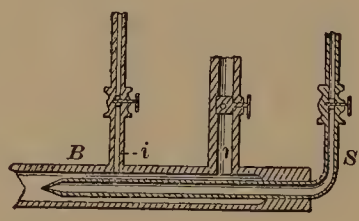
Fig. 2620.

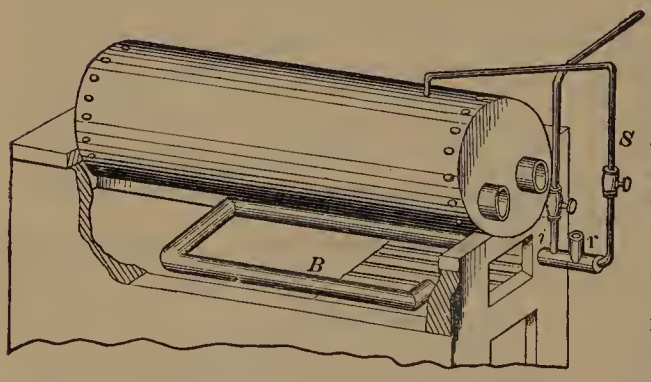


Hydraulic Wheel.

it may be pan of sand upon whose surface the oil is ignited. See GAS-HEATER; GAS-STOVE.

Fig 2621





Hydrocarbon Boiler-Furnace.

Hy'dro-car'bon – fur'nace. One specially adapted to the use of liquid fuel either beneath a steam-boiler or a metallurgic furnace. See HYDRO-CARBON-BURNER.

Hy'dro-car'bon–stove. A heating or cooking stove in which liquid fuel is burned within the furnace chamber. See GAS-STOVE.

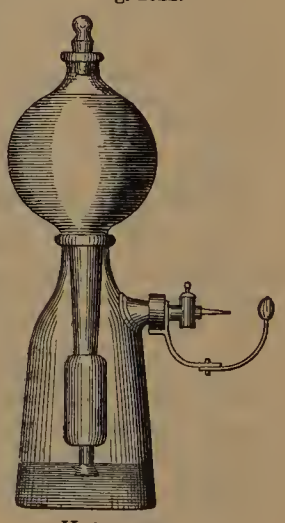
Hy'dro–e-lec'tric Bat'ter-y. (*Electricity.*) An apparatus in which dynamic electricity is produced by means of two different metals connected together by a conductor, and immersed in a solution which causes a flow of electricity from the positive to the negative metal. See GALVANIC BATTERY.

Hy'dro–e-lec'tric Ma-chine'. (*Electricity.*) A machine invented in 1840 by Mr. (now Sir William) Armstrong, in which electricity is generated by the friction of steam against the sides of orifices through which it is allowed to escape under high pressure. A steam-boiler is supported on four glass legs. The steam is conducted over wet cotton wicks before escaping, in order to take up water whose friction against the sides of the orifice is the generator of the electricity, the steam being the driving power. The positive electricity is collected by directing the jet of steam upon a metallic comb communicating with an insulated conductor.

Hy'dro–ex-tract'or. A form of filter or dryer in which a liquid is driven by centrifugal force from or through a mass deposited in a chamber rotating at high velocity. See CENTRIFUGAL MACHINE.

Hy'dro-gen-lamp. About 1825 a German named Döbereiner discovered that spongy platinum became incandescent when a mixture of hydrogen gas and atmospheric air was passed through it, and thence devised his self-lighting lamp, which was long in favor and known as the hydrogen-lamp. It formed an instantaneous light apparatus, and was especially useful for lighting at intervals during the day.

Fig. 2622.



Hydrogen-Lamp.

It has lately been applied to gas-burners,

which are self-igniting as the jet of carburetted hydrogen is ejected upon a piece of spongy platinum suitably placed in proximity to the orifice.

Hy'dro-met'al-lur'gy. The wet process of extracting metals from ores; in contradistinction to the hot process. See list under METALLURGY.

Hy-drom'e-ter. 1. An instrument for determining the relative densities of liquids. Distilled water is usually referred to as the standard of comparison. It consists essentially of a bulb or float weighted at bottom so as to float upright, and having an elongated stem graduated to indicate the density of the liquid by the depth to which it sinks therein. Hydrometers may be divided into two classes; those with which weights are used and those in which they are dispensed with. Among the former are Sykes's, Jones's, and Siemen's, while Tralle's and many others are of the latter description.

In all, a correction must be applied to the observed indication when the temperature is above or below a certain standard (usually 60° Fah.), in order to obtain the true result.

Many instruments are only constructed with reference to liquids heavier than water; such are *saccharometers*, *salinometers*, and *acidimeters*, which, though bearing names, specifically indicating the particular kinds of fluids they are designed to test, are embraced in the general class hydrometer; such also are those adapted for fluids lighter than water, as *alcoholometers* and *oleometers*; all depend on the same principle, but greater delicacy is secured by confining the measuring capacity of the instrument within comparatively narrow limits, allowing it much greater vertical ranges for equal variations in specific gravity, so that extremely small differences become sensible. The different weights in those of the weighted class are also intended for this purpose.

Hydrometers are made and specially graduated for testing spirits, petroleum, oil, milk, cream, vinegar, lye, lime-water, acid, ether, alcohol, silver solution, dye solutions, salt water, lime, alkali, sirup, ammonia, beer, bark ooze, cider, shellac, glue, wine, must, urine. See list under METERS.

Sykes's hydrometer is that legally employed in the collection of the revenue in Great Britain. It has a flat stem graduated into eleven equal parts, which are again subdivided into two.

Fig. 2623.

Sykes's Hydrometer.

Eight different weights, numbered respectively 10, 20, 30, 40, 50, 60, 70, 80, are employed in connection with the instrument.

The proper one to be used depends on the strength of the spirit to be tested. It is placed on the lower projecting stem, sinking the instrument to a depth corresponding or nearly so to some one of the graduations on the upper stem; this is noted, and also the temperature of the liquid, and the corresponding strength per cent of spirit is then found from tables constructed for the purpose.

Jones's hydrometer is a modification of Sykes's. It has a square stem, differently graduated on each of its four sides, and three weights which, with the unweighted instrument, correspond to the four scales.

Among those in which weights are dispensed with are Beaumé's, the centigrade, etc.

Beaumé's is in very general use in France and on the Continent of Europe. Its scale is based upon a solution containing 10 per cent of chloride of sodium (common salt).

The following table shows the specific gravity corresponding to different degrees of Beaumé:—

For Liquids heavier than Water.

Degrees Beaumé.	Specific Gravity.	Degrees Beaumé.	Specific Gravity.	Degrees Beaumé.	Specific Gravity.
0	1.000	26	1.206	52	1.520
1	1.007	27	1.216	53	1.535
2	1.013	28	1.226	54	1.551
3	1.020	29	1.236	55	1.567
4	1.027	30	1.246	56	1.583.
5	1.034	31	1.256	57	1.600
6	1.041	32	1.267	58	1.617
7	1.048	33	1.277	59	1.634
8	1.056	34	1.288	60	1.652
9	1.063	35	1.299	61	1.670
10	1.070	36	1.310	62	1.689
11	1.078	37	1.322	63	1.708
12	1.086	38	1.333	64	1.727
13	1.094	39	1.345	65	1.747
14	1.101	40	1.357	66	1.767
15	1.109	41	1.369	67	1.788
16	1.118	42	1.382	68	1.809
17	1.126	43	1.395	69	1.831
18	1.134	44	1.407	70	1.854
19	1.143	45	1.421	71	1.877
20	1.152	46	1.434	72	1.900
21	1.160	47	1.448	73	1.924
22	1.169	48	1.462	74	1.949
23	1.178	49	1.476	75	1.974
24	1.188	50	1.490	76	2.000
25	1.197	51	1.505		

For Liquids lighter than Water.

10	1.000	27	.896	44	.811
11	.993	28	.890	45	.807
12	.986	29	.885	46	.802
13	.980	30	.880	47	.798
14	.973	31	.874	48	.794
15	.967	32	.869	49	.789
16	.960	33	.864	50	.785
17	.954	34	.859	51	.781
18	.948	35	.854	52	.777
19	.942	36	.849	53	.773
20	.936	37	.844	54	.768
21	.930	38	.839	55	.764
22	.924	39	.834	56	.760
23	.918	40	.830	57	.757
24	.913	41	.825	58	.753
25	.907	42	.820	59	.749
26	.901	43	.816	60	.745

In Gay Lussae's centigrade hydrometer the specific gravity of a liquid heavier than water is found by subtracting the indication from 100 and dividing 100 by the remainder; if lighter than water, add the indication to 100 and divide 100 by the sum, thus 10° below $0° = \frac{100}{90} = 1.111$ specific gravity; 10° above $0° = \frac{100}{110} = 0.909$ specific gravity.

The hydrometer of Brix is that legally used in Prussia; to ascertain the specific gravity the constant number, 400, is divided by 400 + the indication for liquids lighter than water, and by 400 − the indication for those heavier than water.

The formula for Beck's instrument is precisely similar, substituting 170 for 400.

Tralle's and Gendar's are used in the United States, the former being adopted by government for ascertaining the duty on distilled spirits. It is graduated from 0°, the indication in water, to 100°, alcohol, 50° being proof spirit. A correction is required for temperatures above or below 60° F.

The volume of pure spirit is ascertained (1) when above proof by multiplying the indication by 2 and subtracting 100; and (2) when below proof by multiplying the indication by 2 and subtracting the product from 100.

The commercial hydrometer, Gendar's, is graduated to 100° each way from proof. To ascertain the per cent of pure spirit: when the liquor is above proof, add 100 to the indication and divide the sum by 2; when below proof subtract the indication from 100 and divide the remainder by 2.

Rousseau's hydrometer, designed for ascertaining the specific gravity of very small samples of liquids, has a cup on the upper part of the stem in which a known amount, as one gramme, of the fluid is placed; the degree of submergence of the stem compared with that caused by an equal volume of distilled water gives the density of the fluid.

There are also hydrometers which indicate the density by means of a steelyard, having on one arm a vessel which is *in equilibrio* in a tank when empty. The mark on the other arm of the scale, at which the weight must be placed to maintain the equilibrium when the vessel is filled with liquid, determines its specific gravity.

Twaddel's hydrometer is used in England for liquids heavier than water. Its degrees are converted into specific gravities by multiplying them by 5, adding 1,000, and dividing the sum by 1,000. Thus, —

$$20° \text{ Twaddel} = \frac{20 \times 5 + 1{,}000}{1{,}000} = 1.100$$

The density of liquids may also be determined by means of a series of glass beads of different specific gravities; the heavier sink and the lighter float on the surface, while one that indicates the precise specific gravity, which is marked in thousandths on its surface, remains in equilibrium at any depth in the liquid.

The subject is fully discussed in Kuppfer's "Handbuch der Alkoholometrie," Berlin, 1865.

See also ALCOHOLOMETER, ACIDIMETER, AREOMETER, SACCHAROMETER, etc. See list under METER; see also UNIT.

The most familiar hydrometer, to many, is a hen's egg, used by a farmer's wife to test the strength of lye for making soap. When it floats as large as a quarter-dollar above the liquid the strength is satisfactory. Others test it by its action on a feather.

Small hollow glass spheres called bubbles are also used in testing spirits, the rate at which they ascend therein being a gage of the gravity of the liquid.

The hydrometer was in all probability invented by Archimedes, who was killed in the storming of Syracuse, 212 B. C. His discovery of the mode of ascertaining specific gravity by displacement of liquid is referred to by many writers of Europe, Asia, and Libya.

Seneca, Pliny, and Galen, who flourished during the first and second centuries of our era, and whose writings refer to the methods then in use of ascertaining the specific gravity of solids and fluids, appear unacquainted with the hydrometer, though the instrument is clearly described by Priscian, who died about A. D. 528.

Synesius of Ptolemais wrote to Hypatia that he wished to use a *hydroscopium*, and requests that she would cause one to be constructed for him. He says, "It is a cylindrical tube, the size of a reed or pipe, a line is drawn upon it lengthwise, which is intersected by others, and these point out the weight of water. At the end of the tube is a cone, the base of which is joined to that of the tube, so that both have but one base. This part of the instrument is called *baryllion*. If it be placed in water it remains in a perpendicular direction, so that one can readily discover by it the weight of the fluid."

Hypatia was brutally murdered by a mob of Alexandrine monks, instigated by Cyril, A. D. 414. With the death of Hypatia expired another period of intellectual research. Cyril was the president of the council which condemned Nestorius. After a dreary interval of several centuries, philosophy again revived in the city of Alexandria, while the Papacy shrank out of Asia and Africa, ejected from the great capitals Antioch, Jerusalem, and Alexandria; the Nestorians became the tutors of Mesopotamia and Chaldea, and in connection with the Jews founded colleges. Among these, that of Djondesabour first instituted a system of academical honors which has descended to our time. This college was patronized by the Khalif Haroun al Raschid, who forbade any one practicing medicine until after a satisfactory examination at the college of Djondesabour or that of Bagdad.

The areometer used by the Saracens about A. D. 1000, and for many centuries, was a form of hydrometer. It is described by Abu-Jafar Al-Khâzinî, an eminent Saracenic writer of the twelfth century, and is credited to Pappus, a Greek philosopher, who was contemporary with Theodosius the Great, A. D. 379 – 395. Al-Khâzinî refers to the original discovery of Archimedes, upon which the instrument is based, and takes a very pious view of the line of discovery. See the "Book of the Balance of Wisdom," in Vol. VI. of the "Journal of the American Oriental Society," New Haven, 1860. See *supra*, pp. 141, 142.

In the sixteenth and seventeenth centuries, the salinometer was used in the salt-works of Germany, and is referred to as a well-known invention. Pepys, in his "Diary," December 10, 1668, refers to Boyle's hydrometer as "a bubble to try the strength of spirits with."

2. A current gage; known also as a *tachometer*, *rheometer*, *hydrometric pendulum*, *Woltmann's mill*, etc.

Hy'dro-met'ric Pend'u-lum. A *current-gage*. An instrument consisting of a ball suspended from the center of a graduated quadrant, and held in a stream to mark by its deflection the rate of motion of the water.

Hy'dro-met'ro-graph. An instrument for determining and recording the amount of water issuing from a pipe, etc., in a given time.

Hy'dro-phore. An instrument for obtaining specimens of water from any given depth below the surface.

Hy'dro-scope. 1. An instrument anciently used for measuring time by the trickling of water from an orifice in the lower end of a graduated tube. The hight, diameter, and graduation of the tube, and the size of the opening, being properly proportioned, the subsidence of level of the water indicates the passage of time. See CLEPSYDRA.

2. An instrument to detect the presence of moisture in air. See HYGROMETER.

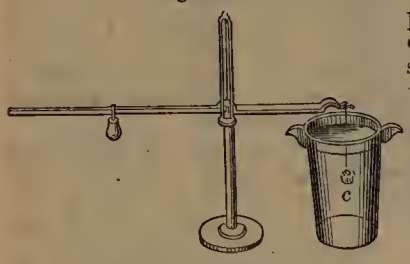
Hy'dro-stat. A general term, signifying an apparatus or contrivance to prevent the explosion of steam-boilers. The devices are numerous, and have specific names.

Hy'dro-stat'ic Arch. (*Architecture.*) A linear

arch suited for sustaining normal pressure at each point, proportional — like that of a liquid in repose — to a depth below a given horizontal plane. It is sometimes called the "Arch of Yvon-Villaceaux," from the name of the mathematician who first demonstrated its properties. — RANKINE.

Hy'dro-stat'ic Bal'ance. A balance for weighing substances in water for the purpose of ascertaining their specific gravities.

Fig. 2624.



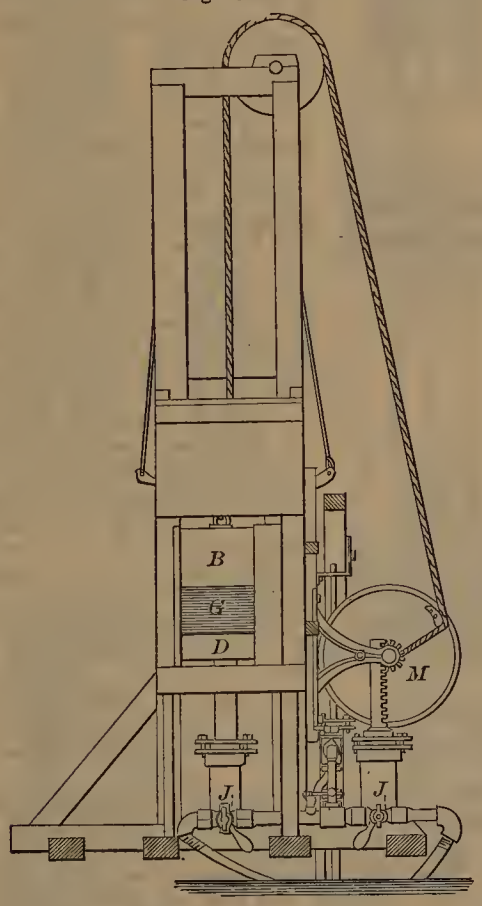
Hydrostatic Balance.

When unloaded, the arms are equipoised. *c*, the body to be weighed, is suspended from the shorter arm. On the longer arm the movable weight indicates the weight of the object in air or water. A *specific-gravity balance*. See AREOMETER.

Hy'dro-stat'ic Bal'ing-press. One in which the force of water under pressure is made to compress the fibrous material to be baled.

In the example shown, the beater *B* is first operated, and, when the process has gone to a certain extent, the beater is made stationary, and the follower *D* raised. Both operations are effected by hydraulic

Fig. 2625.

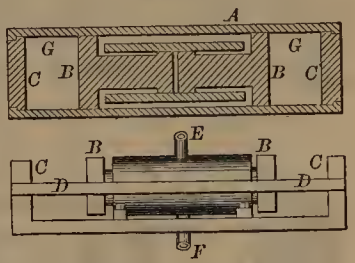


Hydrostatic Baling-Press.

operation. The suspension rope of the beater winds on the wheel *M*, which is rotated by pinion and rack, the latter being depressed by a piston in cylinder *J*. The rope is tripped off the wheel from time to time, automatically, allowing the weight *B* to fall, and again and again re-winds and slips off. At the proper time the cock is turned and the water turned on to the other cylinder *J*, beneath the follower *D*, and the latter is raised by the pressure of water beneath the piston in said cylinder. *G* represents the material under pressure.

In Fig. 2626 the motive-power is water under pressure. The cylinder *A* is open at both ends, has two ports, *E* and *F*, at the center, to receive and discharge respectively the water from the pump or head. There are two rams *B* in cylinder *A*, working in opposite directions toward heads *C*. *G* is the space for the material to be pressed. *D* are connecting-rods, connecting the heads *C* together to resist the strain of the rams *B*, and forming guides for the rams.

Fig. 2626.



Hydrostatic Baling-Press.

Hy'dro-stat'ic Bed. A bag of india-rubber cloth inflated with water. Intended for bedridden or wounded persons; invented by Dr. Arnott, and described in his "Elements of Physics."

Hy'dro-stat'ic Bel'lows. An instrument for illustrating the fact that the pressure of a small column of water balances that of another column of water, no matter how large. Water poured into the funnel-mouthed tube *a* (*I*, plate opposite page 1150) flows into the flexible-sided box *b*, and raises a weight *c* many times greater than its own. The weight may be lifted in this way until the combined pressure of it and the column of water in the bellows *b* is equal to that of a column of water having an equal surface and as high as the column in the tube *c*.

Bramah's and other hydrostatic or hyraulic presses depend on this principle.

Hy'dro-stat'ic Lamp. A lamp in which a supernatant stratum of oil is sustained by water or other fluid of greater specific gravity than the oil. Salt and water, sirup, honey, mercury, and sulphate of zinc in solution, have been employed for this purpose.

Hy'dro-stat'ic Lev'el. (*Civil Engineering.*) A water-level. See LEVEL.

Hy'dro-stat'ic Press. A machine in which the pressure of a piston on a body of water of relatively small sectional area is made to propagate the force to a cylinder of multiple area, where the force is directly as the difference and the speed inversely as the difference.

Pascal (1650) demonstrated the power of a column of water in a vertical pipe inserted into a barrel. In filling the barrel and pipe, he found the pressure to be as the hight of the column and the area of the base, as if the cask had preserved its diameter throughout the whole length of the column. Supposing the barrel to have an area of three square feet, and the pipe of twelve feet length to have a capacity of two pints, the effective pressure of the quart of water on the heads of the cask is equal to a cylinder of water containing thirty-six cubic feet.

If a properly fitting piston of a weight equal to the quart of water be placed in the pipe, it will have the same effect as the water for which it is a substitute.

If, instead of the mere weight of the piston, it be loaded with a weight nine times that of its own, the bursting pressure in the barrel will be tenfold greater than before.

If, instead of a weight upon the piston, a lever be placed above it, the increased force may be immensely multiplied and a power obtained which is beyond all others of equal compactness and facility of manipulation.

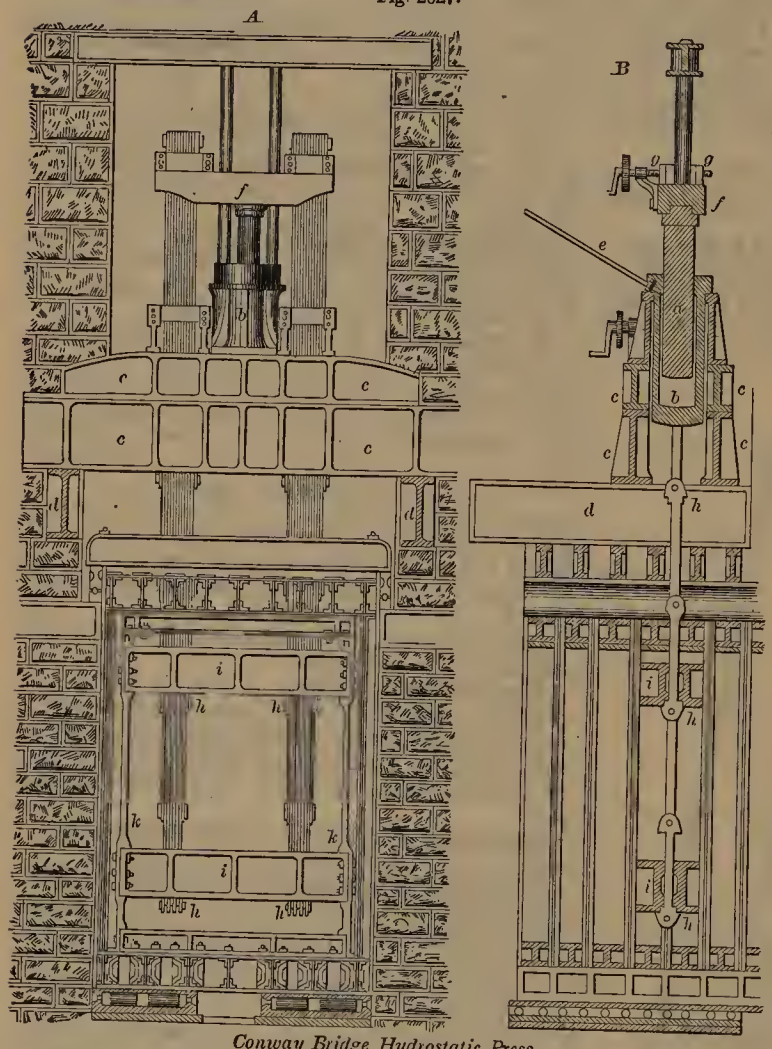
This is the Bramah hydraulic press.

The first one ever made is in the museum of the Commissioners of Patents (England), and is inscribed, "Bramah, Invt. et fect. 1796."

The celebrated Maudslay was mechanically educated in Bramah's shop.

In *N* (page 1157) the operation of this machine may be readily understood. *a* is a reservoir of water on which is a pump, the piston-rod *b* of which is worked by the hand-lever *c*. The water is conveyed by the pipe *d* to the cylinder *e*, where it elevates the piston *f* and table *g*, which rises between the guides that hold the upper plate, against which the object under pressure is driven. The elevation of the table *g* is proportionate to the quantity of water injected. The power is proportionate to the respective areas of the pump and the cylinder *a*.

Fig. 2627.



Conway Bridge Hydrostatic Press.

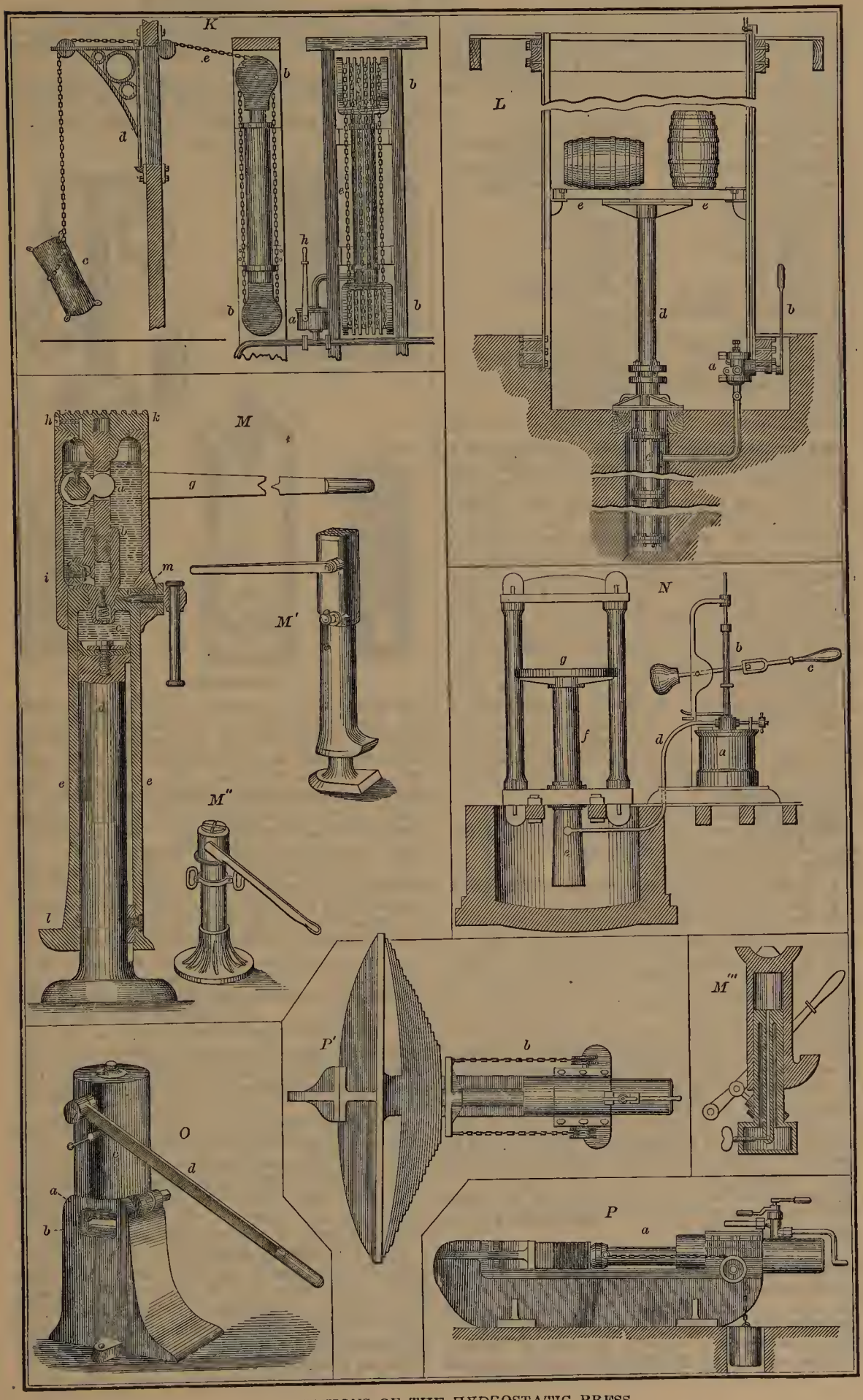
Fig. 2627, *A* is an elevation of the press and cross-section of the tube employed in the Conway tubular bridge, and *B* a vertical section of the press and a portion of the tubing. *a* is the pump piston and *b* the cylinder, which is supported upon double iron girders *c c*, resting on girders *d*, built in the masonry. Water is forced through the pipe *c* into the cylinder by an engine of 40-horse power. The piston has a cross-head *f* provided with clamps *g* which hold the ends of the lifting chain links and are screwed up firmly against them. The alternate links are notched, as shown at *h h*, so as to fit into corresponding grooves in the cross-girders *i i*, which are temporarily bolted to the walls *k k* of the tube. The force actually exerted by the pump in raising one end of the tube, a weight of 900 tons, was two and a quarter tons per square inch.

Three hydrostatic presses were used at the raising of the tubes of the Menai Railroad Bridge. One of them worked at one end of the tube and two smaller ones at the other end. The larger one had a cylinder 11 inches thick and 20 inches in internal diameter. Its lift was 6 feet. The weight of the cylinder was 16 tons, and of the machine 40 tons. Its power was estimated as equal to that of 30,000 men. The smaller presses had rams 18 inches in diameter.

The presses stood on the summits of the piers, and lifted by means of chains having alternately eight and nine links. The weight of a chain was 224,000 pounds. They were attached to the rams by iron cross-heads of great thickness. The two chains passed through square holes at each end of the cross-head, and were gripped above by clamps of wrought-iron, screwed like a vise. At the lower end, the chains were attached to the tube, or rather to lifting-frames within its extremities, by three sets of massive cast-iron beams, crossing one above another, and secured by wrought-iron straps passing over the upper pair and descending into the bottom cells where they were keyed. The ends of the chains fitted under deep shoulders or notches in the lifting-frames, where they were secured by screw-bolts; these lifting-frames and beams added 448,000 pounds to the weight to be lifted. Each of the middle tubes weighed 4,032,000 pounds (1,800 English tons), and they were lifted by successive lifts of 6 feet to a hight of 100 feet above tide-water. The motive force was two steam-engines of 40-horse power each, and the water was delivered through a ½-inch pipe into the cylinder below the ram.

That shown at *D*, plate opposite page 1150, is adapted for pressing the printed sheets of books, etc. It is arranged with either one or two pumps for forcing water into the lifting-cylinder, whose piston raises the platform on which the sheets are placed. This is kept in horizontal position by upright standards, and between it and the head of the press the sheets are compressed.

In the *sterhydraulic* press of MM. Desgoffe and Olivier, a coil of gut-rope passing through a stuffing-



APPLICATIONS OF THE HYDROSTATIC PRESS.

box into the cylinder is wound upon an interior pulley, displacing part of the fluid (oil) and causing the piston to rise. See HYDRAULIC PRESS, Fig. 2617. Among the applications of the hydrostatic press may be found : —

Accumulator.	Hydraulic slip.
Boiler-power.	Hydraulic spring-tester.
Coal-breaking jack.	Hydrostatic baling-press.
Crank-puller.	Hydrostatic bellows.
Hydraulic crane.	Jim-crow.
Hydraulic dock.	Pipe-prover.
Hydraulic elevator.	Punching-bear.
Hydraulic hoist.	Rail-bender.
Hydraulic lift.	Rail-punch.
Hydraulic lifting-jack.	Shaft-straightener.
Hydraulic platform-lift.	Ship-jack.
Hydraulic press.	Spring-tester.
Hydraulic pulling-jack.	Testing-machine.
Hydraulic punch.	Traversing-jack.
Hydraulic shaft-straightener.	Wagon-tipper.
	Wheel-jack.
Hydraulic shears.	Wheel-press.

Hy′dro-stat′ic-press Pump. A pump used in hydrostatic presses. The example (*A*, plate opposite page 1150) gives one form. *q* is the water-cistern and *r* the pump-barrel, which has a sucking tube *t* and a conical valve *s*. The plunger is operated by the lever, which may be pivoted in either of the holes shown at *x* on the standard, to obtain greater or less quickness of stroke ; it is connected with the standard by a link. *k* is a safety-valve and *z* the discharge-valve, the rise and fall of which is regulated by a screw placed over it. On lifting the plunger, water is drawn into the barrel *r* through the tube *t*, and by depressing it the water is forced out through the pipe *j*, the valve *z* rising to permit its passage. See also *C D*, same plate.

Hy-et′o-graph. A chart indicating the comparative distribution of rain over a given geographical surface. See list under 'GRAPH. See also MAP, for list of lines indicating equal conditions of natural phenomena.

Hy′gro-graph. A recording hygrometer.

Hy′grom′e-ter. An instrument for measuring the comparative moisture of the air.

They are of three kinds : —

1. Those which act on the principle of *absorption*.
2. Those which act by *condensation*.
3. Those in which the hygrometric condition is deduced from observations of a wet and a dry bulb.

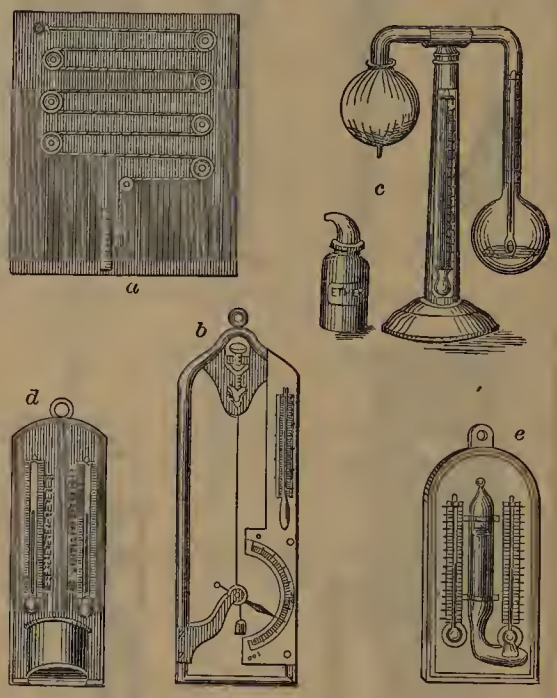
1. *a*. Of the first class is the *hygrometer* of Saussure (died 1799). It consists of a human hair boiled in lye, and acts by absorption and evaporation, as shown at *a*, Fig. 2628. A piece of catgut may be made to extend from a pin at one end, over a number of pulleys, and terminate at the lower end with a small weight, which rises and falls with changes in the length of the cord, induced by hygrometric changes in the atmosphere.

A hygrometer, or *weather prophet*, may be constructed by taking a cigar-box and inserting at its center an upright pivoted shaft with two horizontal arms. Around this are wound two turns of a catgut string, one end of which is fastened to a staple at one end and the other to a spiral spring at the other end of the box.

Fluctuations in atmospheric humidity cause the string to extend or contract, as the case may be, turning the shaft partially round. If to the end of one arm a toy figure of a mower be attached, and to the other a figure holding an umbrella, openings being cut to represent doors in the side of the box, fronting each figure, the figure holding the umbrella will come out when the air is moist and retire as the weather becomes dry, allowing the mower to come forth.

In *b*, a human hair is fastened at the upper end to a screw, and at the lower end passes over a pulley which has a radial pointer. A weight keeps the

Fig 2628.



Hygrometers

hair tight, and its expansion or contraction causes the pointer to traverse on the graduated arc. Moisture makes the hair longer, and allows the pointer to rise, and dry weather has the reverse effect. The 0° and 100° form the extremes of dryness and wetness: one is obtained from an atmosphere artificially dried, and the other by the absolute saturation of the air with moisture. The intervening space is then divided into 100 equal parts.

b. An alcoholic solution of camphor, saltpeter, and muriate of ammonia, in a glass tube, has been suggested for a weather guide. Changes of weather are stated to render the solution turbid, or clear it, as the condition may be. Its value is doubtful.

c. An arm is balanced upon an axis so as to be horizontal at the zero point, and provided at one end with an absorbent substance, such as a piece of sponge. When the air is relatively moist the sponge will absorb water and become heavier, so that the pointer rises against the graduated arc and indicates rain ; conversely, dry air causes the sponge to part with some of its moisture, and, becoming lighter, the pointer falls.

2. Daniell's hygrometer *c* determines the moisture of the air by indicating the dew-point, or the temperature at which moisture is deposited by the air. It consists of a bent tube of glass with a bulb at each end. The legs of the tube are of unequal length, and the lower one, which is of black glass, contains a little ether, into which dips the bulb of a small and delicate thermometer, whose stem occupies the cavity in the leg of the tube. The whole tube contains ether and its vapor, the air having been removed. The upper bulb is covered with a piece of muslin. The support of the instrument has another thermometer by which the temperature of the air is denoted.

When an observation is to be made, a little ether is poured upon the muslin; this evaporates and cools the contents of the tube, abstracting heat from the lower bulb by the vaporization of its contents. As soon as the lower bulb has cooled sufficiently to condense the moisture of the atmosphere, dew will be observed to condense upon it, and the temperature is to be noted as indicated by the thermometer in the tube. If the air be moist, dew will commence to deposit on the lower bulb on a slight reduction of temperature; if the air be dry, it will require a relatively greater reduction of temperature. The point at which moisture commences to form on the bulb is the "dew-point," and this ascertained, in connection with the temperature of the air, will enable the hygrometric condition of the air to be determined by tables prepared for the purpose; as to the elasticity and density of the aqueous vapor, its weight in a cubic foot of air; the degree of dryness either upon the scale of the thermometer or the hygrometer, and the rate of evaporation.

In the climate of England the dew-point is seldom more than 30° below the temperature of the air, but in the Deccan, in India, with the temperature of the air at 90°, the dew-point has been seen at 29°,—making the degree of dryness 61° thermometric.

Professor Daniell states that "the more accurate mode of expressing the moisture of the air from an observation of the temperature and dew-point is by the quotient of the division of the elasticity of the vapors at the real atmospheric temperature, by the elasticity at the temperature of the dew-point; for, calling the term of saturation 1,000, as the elasticity of vapor at the temperature of the air is to the elasticity of vapor at the temperature of the dew-point, so is the term of saturation to the observed degree of moisture.

"Thus with regard to the observation in the Deccan — 1.430 : 0.194 : : 1000 : 135, — the fourth term is the degree of moisture on the hygrometric scale."

3. *d e* are two different forms of Mason's hygrometer. In this two thermometers are placed side by side, the bulb of one being covered with muslin or similar material, and wetted with water when an observation is to be made. The dimished temperature of the wet bulb, due to the evaporation of the moisture, is compared with the natural temperature of the other bulb; the temperature and the difference afford the data for determining the hygrometric conditions.

In *e* the bulb of one thermometer is kept constantly moist from a cistern fixed on the plate, to which the two are attached.

This is the most useful form of hygrometer. The theoretical relation between the indications of the two bulbs and the humidity of the air is rather complex and has given rise to much debate; it is usual to effect the reduction by tables which have been empirically constructed by comparison with the indications of the *dew-point* instrument of Daniell. The British tables for this purpose were constructed by Glaisher; edition of 1856 preferred. They are based upon a comparison of the simultaneous readings of the wet and dry bulb thermometers, and of Daniell's hygrometer, taken for a series of years in Greenwich Observatory, in Toronto, and in India. The ratio between the two readings is not equal at all degrees of temperature as marked on the dry bulb. When this temperature — the *natural*, it may be called — is 53° F. the *dew-point* is as much below the *wet bulb* as the latter is below 53° F., the temperature of the air. At higher temperatures the wet-bulb reading is nearer to the dew-point than to the air-temperature, and the reverse is the case at temperatures below 53° F. See PSYCHROMETER.

Two citations from "Cosmos" are not irrelevant: "In the brilliant period of the foundation of 'mathematical natural philosophy,' attempts to investigate the moisture of the atmosphere in its connection with variations of temperature and with the direction of the wind were not wanting. The Academia del Cimento conceived the happy idea of determining the quantity of vapor by evaporation and precipitation. The oldest Florentine hygrometer was accordingly an apparatus in which the quantity of precipitated water run off was determined by weight. To this condensation hygrometer, which, aided by the ideas of LeRoy, has gradually led in our own days to the exact psychrometric methods of Dalton, Daniell, and Auguste, there were added, according to the example previously set by Leonardo da Vinci, the absorption hygrometers, made of animal or vegetable substances, of Santorio (1625), Torricelli (1626), and Molyneux. Catgut and the beard of the wild oat were used almost at the same time. Instruments of this kind, founded on the absorption of the aqueous vapor contained in the atmosphere by organic substances, were provided with indexes and counterpoises, and were very similar in construction to Saussure's and Delue's hair and whalebone hygrometers; but the instruments of the seventeenth century were deficient in the determination of fixed wet and dry points, so necessary for the comparison and understanding of the results. This desideratum was at last supplied by Regnault, but without reference to the variation which might be occasioned by time in the susceptibility of the hygrometic substances employed. Pictet, however, found that the hair of a Guanche mummy from Teneriffe, which might be a thousand years old, employed in a Saussure's hygrometer, still possessed a satisfactory degree of sensibility."

"'The admiral' [Columbus], says Fernando Colon, ascribed the many refreshing falls of rain which cooled the air whilst he was sailing along the coast of Jamaica, to the extent and density of the forests which clothe the mountains. He takes this opportunity of remarking, in his ship's journal, that 'formerly there was much rain in Madeira, the Canaries, and the Azores; but since the trees which shaded the ground have been cut down, rain has become much more rare.' This warning has remained almost unheeded for more than three centuries and a half."

Hy'gro-met'ric Bal'ance. An instrument for indicating the relative density of the air, and consequent chances of rain or dry weather. It consists of a balance, from one arm of which is suspended a brass weight and from the other a large, thin, hollow cylinder. The two are arranged so as to be in equilibrium at a given density of the atmosphere, and it is evident that if the air become heavier, the large cylinder, displacing more air than the solid weight, will become more buoyant and ascend. If, on the contrary, the air become lighter, it will sink. A rod descending from the scale-beam serves to indicate, on the graduated arc below, the comparative density of the air at the time of making the observation.

If the air be heavy, fine weather may be expected; but if the cylinder sink, rain usually follows.

Hy'gro-scope. An instrument for indicating the degree of moisture of the atmosphere. See HYGROMETER; Deschanel's "Nat. Phil.," Part II., p. 367. See PSYCHROMETER.

Hy-pæ'thrum. (*Architecture.*) That portion of the interior of a building which is not protected by a roof. The ancient temples, which were entirely uncovered, were said to be hypæthral.

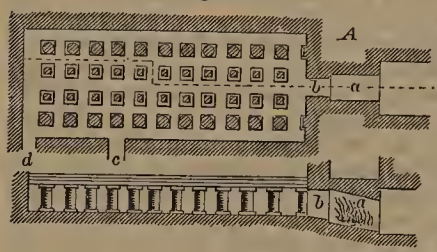
Hy'per-thy'rum; Hy'per-thy'non. (*Architecture.*) That part of the architrave which is over a door or window. See HEAD-MOLDING.

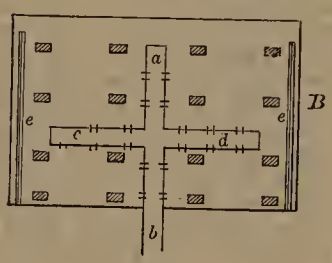
Hy'phen. A mark (-) for joining the parts of a compound word, or indicating a break in a single word at the end of a line.

Hy'po-caust. (*Building.*) A furnace for heating a building by hot air conducted under the floor and through the walls.

They were used by the Romans for heating their baths. One kind was constructed with flues running under the floor, and was heated from the outside of the building, and another was formed like a low chamber, its ceiling supported by small pillars or dwarf walls. This was immediately beneath the baths to be heated, and sometimes had flues leading to other apartments.

Fig. 2629.





Hypocausts.

Fig. 2629, *A*, is a plan and section of one discovered at Lincoln, England. This was 24½ feet long, 9¼ feet wide, and 26 inches high in the clear. The ceiling, which formed the floor of the apartment above, was of large bricks laid in mortar, over which were tiles covered with stucco, the whole being about 10 inches thick. The products of combustion from the fire-chamber *a* passed through the arched opening *b* into the hypocaust, and were, it is supposed, discharged at *d*; *c* is believed to have been a flue leading to another apartment. The large fire space was necessary, as the Romans did not employ chimneys for increasing the draft.

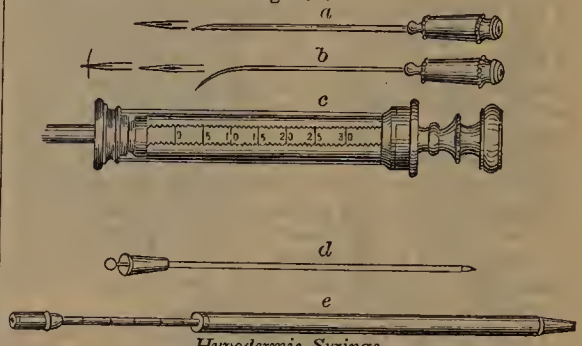
Hypocausts are in general use in Northern China, where the winters are severe. *B* illustrates their mode of construction. They are located beneath the floor of the house, and have two flues *a b*, *c d*, at right angles. These have a number of openings, which distribute the heat to all parts of the floor, which is paved with tiles or flagstones. *e e* are flues for carrying off smoke. The seats and sleeping-places are also heated by this arrangement. They are built of brick and are hollow, communicating with the hypocaust below. The fuel employed is composed of a mixture of fine coal, clay, earth, cow-dung, or refuse vegetable matter, formed into balls and dried. In houses of an inferior class, a sort of stove, built into one corner of the room, is used.

Hypocausts were in use by the emirs of Cordova, from the ninth to the thirteenth century, the heat being conveyed by caliducts to the winter apartments. See BATH; HEATING-APPARATUS.

Hy'po-der'mic Syr'inge. (*Surgical.*) An instrument for administering subcutaneous injections of solution of morphia, for the purpose of relieving pain. It consists of a syringe with graduated barrel or rod, and a canula of silver or steel which has a point for penetration and an opening for ejection of the liquid. The illustration *a b c* shows a form with a glass tube, a graduated rod, and detachable points of two shapes.

d e is a form of hypodermic syringe to be carried in a pocket-case. The point, inclosing the wire-

Fig. 2630.



Hypodermic Syringe

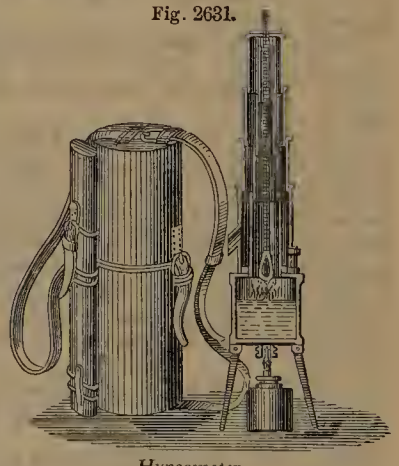
cleaner, fits into a hollow graduated piston. The barrel is an ordinary silver tube, the size of No. 10 catheter, and is six inches long. See also ACUPUNCTURATOR.

Hy'po-tra-che'li-um. (*Architecture.*) The necking of a column in the classical orders, consisting of several narrow cinctures cut into the shaft at the base of the echinus.

Hyp-som'e-ter. An instrument for measuring hights by observing differences in barometric pressures at different altitudes.

Notably, an instrument for determining altitudes by observation of the boiling-points of water. It has a water-vessel, lamp, and thermometer. The example shows the instrument and the case in which it is packed for transportation on the back of a tourist or attendant.

Fig. 2631.



Hypsometer.

Wollaston's apparatus for measuring hights by the temperature of boiling water has a mercurial thermometer with a very large bulb and a stem, which has a length of one inch for every degree of the scale. This is read by a vernier to thousandths. It is found that a difference of barometric pressure of 0.589 inches is equivalent to 1° in the boiling-point, or 530 feet of ascent at moderate elevations.

Tables have been constructed for use with the apparatus, showing the precise elevation corresponding to different temperatures of boiling water.

Hys'ter-om'e-ter. An instrument for ascertaining the size of the uterus.

Hys'ter'o-tome. (*Surgical.*) A knife for operations upon the womb; notably the Cæsarian section.

I.

Ice-an'chor. (*Nautical.*) A bent bar whose prong enters a hole in the ice; to the other end a mooring-hawser is bent.

Ice-ap-pli'an-ces. See: —

Ice-anchor.	Ice-hook.
Ice-apron.	Ice-house.
Ice-beam.	Ice-leveler.
Iceberg-alarm.	Ice-locomotive.
Ice-boat.	Ice-making.
Ice-box.	Ice-marker.
Ice-breaker.	Ice-pick.
Ice-calk.	Ice-pitcher.
Ice-carriage.	Ice-plane.
Ice-chain.	Ice-plow.
Ice-chest.	Ice-preserver.
Ice-chisel.	Ice-safe.
Ice-claw.	Ice-sandal.
Ice-cream freezer.	Ice-saw.
Ice-creeper.	Ice-scraper.
Ice-crusher.	Ice-shaver.
Ice-cutter.	Ice-spade.
Ice-cutting machine.	Ice-tongs.
Ice-elevator.	Ice-tools.

Ice-a'pron. (*Hydraulic Engineering.*) An ice-breaker or *starling* to protect the upper end of a bridge-pier. It presents an inclined edge up stream to break a field or cake of floating ice, or to sustain the pressure of a gorge of ice, and prevent the direct dislodging push of the ice upon the pier.

The ice-aprons of the Eads's St. Louis Railway Bridge are 200 feet long and 60 feet wide, and present an angle of 45° to the current. The frames are of squared oak timber, with three-inch oak planking and No. 16 sheet-iron skin.

Ice-beam. A guard-plank at a ship's bow to fend off ice.

Ice'berg-a-larm'. A thermometrical device to indicate the vicinity of icebergs by the cooling of the water, which is made to spring an alarm.

Ice-boat. 1. One employed for traveling on ice.

The *ice-boats* on the Maeze and Y, in Holland, consist of ordinary boats mounted on runners. The boat rests on transverse pieces, which are secured to a pair of parallel runners resembling those of skates. The extremities of the transverse pieces serve as outriggers, from which stays pass to the mast-heads of the craft to preserve the boat from being careened in its cradle when the sails are spread. The lower edge of the rudder is sharpened, to give it a sufficient adhesion to the ice to enable it to swerve the boat.

A boat can be made of a few planks, three skate-irons, a mast and sail, at a cost of a few dollars. The boat is V-shaped, composed of three planks, two forming the sides and one the base, which is the stern. Under each angle are skate-irons hung on pivots to allow swing. The craft is steered by the iron at the apex or bow. The rigging is usually sloop or yacht rig. These boats sail admirably, and may be numbered on the Hudson by scores; something over a hundred being owned by the various clubs and by private persons. Regattas take place on this river during the winter season when the condition of the ice and state of the wind invites. Attempts to utilize ice-boats for passenger and freight travel have not as yet been successful, owing to several uncertainties in themselves and their mode of going, the state of the ice, the state of the wind, and the probable condition of the cargo if the ice break.

2. A steamboat having a sharp and heavily strengthened prow and bow for forcing its way through ice in a harbor to keep a passage open for vessels. A favorite form of prow is a long ram, presenting an inclined edge to the ice, which is lifted by and broken across the sharp back of the ram.

Ice-box. A chest for domestic use for keeping cool provisions liable to spoil in warm weather.

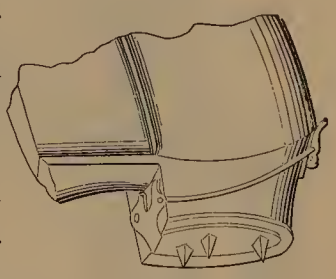
Ice-break'er. 1. *a.* A structure for the protection of bridge-piers, etc. It is of masonry or timber. In the Victoria Bridge across the St. Lawrence at Montreal it is a long, sloping ridge of stone presented up stream, and forming a wedge-shaped starling.

Other ice-breakers are starlings of *piles* or *cribs*. See ICE-APRON. See also PIVOT-BRIDGE.

b. A pier arranged with reference to the current, to prevent access of ice to the vessels in a harbor.

2. An *ice-breaker* for harbors is a steam-vessel provided with means for opening or keeping open a channel for ships.

Fig. 2632.

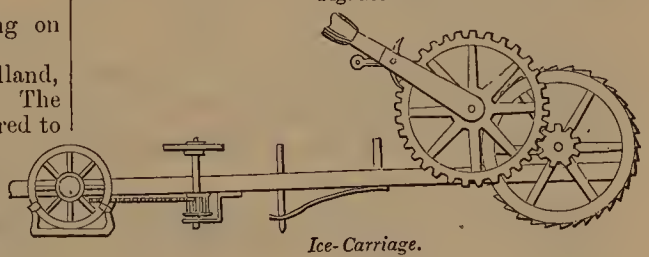


Ice-Calk.

Ice-calk. A spiked plate to be worn on the heel to keep the wearer from slipping on ice.

Ice-car'riage. A platform on runners, and with a means for propulsion on ice. The toothed wheel holds to the ice, and is turned by a small spur-wheel, which is engaged by a larger wheel actuated by a double-ended pawl lever. The

Fig. 2633.



Ice-Carriage.

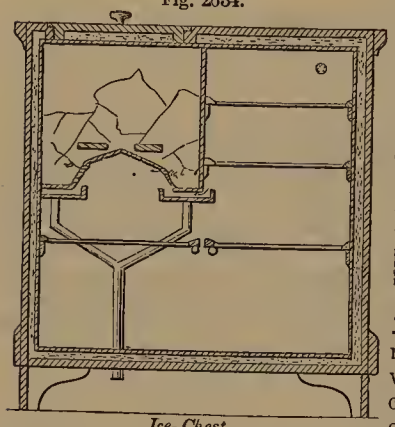
brake consists of a pointed, vertically moving bar, which is ordinarily kept free from the ice by a spring.

Ice-chair. A chair on runners to hold a lady who is pushed along by a skater in the rear.

Ice-chest. A form of domestic ice-chamber having apartments for the ice and the provisions, the food-chamber being cooled by air conducted to it from the ice-box or by the cold side of the latter, which forms a part of the inclosure of the food-chamber. In the example, the ice-box has an arched bottom and perforated depressions that connect with the drip-pans. A large refrigerating surface is thereby exposed to the air of the preserving chamber, and the temperature is reduced by contact of the drip.

Ice-chis'el. A socket chisel with a long handle, used in cutting holes in ice, either in Arctic explorations or as a starting-point for the saw in gather-

Fig. 2634.



Ice-Chest.

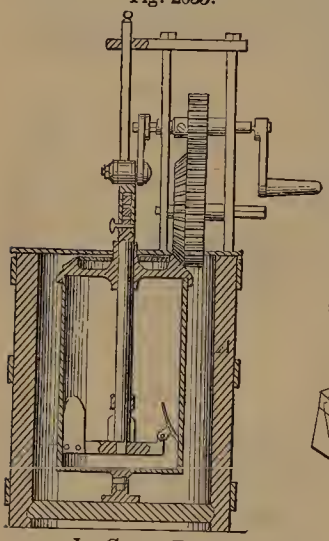
ing ice for use. Also for striking off blocks after they are partially detached by the cutter. See *e f*, Fig. 2658.

Ice-claw. A rope and pair of claws, for grappling ice-blocks. See *k*, Fig. 2658.

Ice-cream Freez'er. A machine in which cream, custard, or lemonade is stirred within a metallic vessel which is plunged in a tub of mingled broken ice and salt.

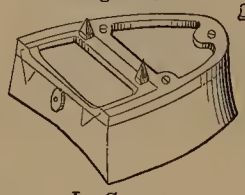
The dasher has vertical reciprocation by the play of a crank-pin in a horizontal slot of its cross-head. The vertical and pivoted scrapers have rotary and reciprocating motions respectively to clear the can sides. The paddles throw the cream outward. The can may be rotated or the dasher reciprocated singly, if desired.

Fig. 2635.



Ice-Cream Freezer.

Fig. 2636.

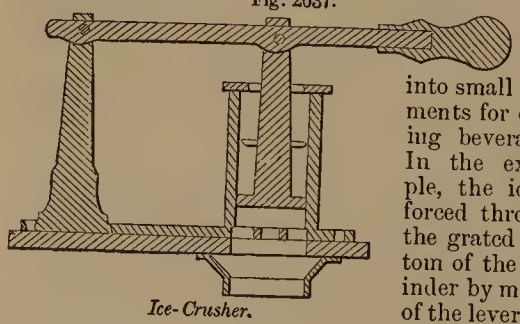


Ice-Creeper.

Ice-creep'er. A socket for the heel of a boot, having spurs to prevent slipping on ice. In the illustration, it is shown inverted.

Ice-crush'er. An implement for breaking ice into small fragments for cooling beverages. In the example, the ice is forced through the grated bottom of the cylinder by means of the lever piston.

Fig. 2637.



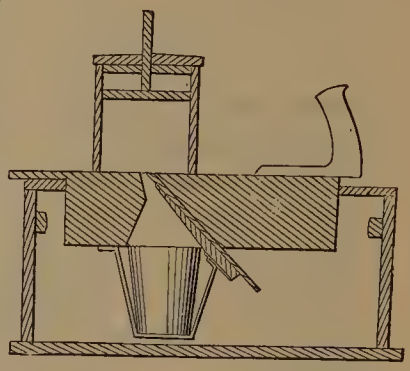
Ice-Crusher.

Ice-cut'ter. A plane for shaving ice for cooling beverages.

In the example, a reciprocating plane moves under a hopper in which is a block provided with a rod for pushing the ice against the plane. Under the hopper and below the plane is a spring for holding a tumbler into which the cut ice falls. See also ICE-PLANE.

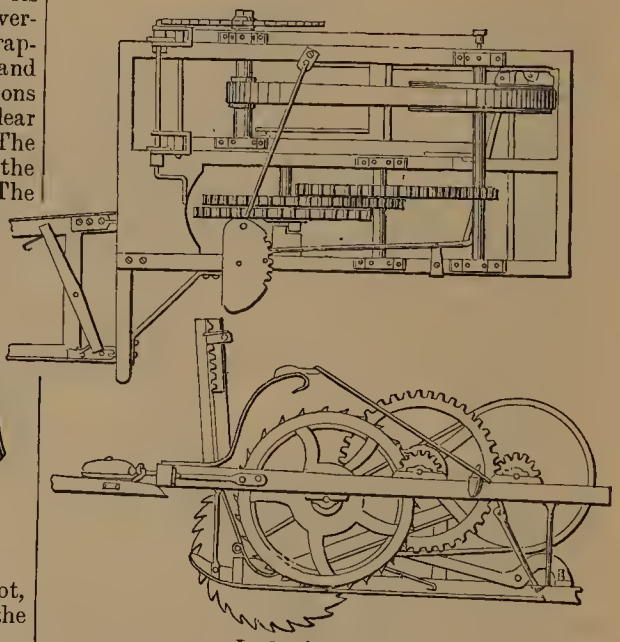
Ice-cut'ting Machine'. One for cutting kerfs in pond ice, to reduce the surface to strips which are afterwards broken into blocks by the axe or spade. In the example, it is a circular saw on a sled, which is drawn by a horse. The saw receives motion from a serrated wheel which engages the ice, and is vertically adjustable by a rack and pinion operating its journal-frame. See also *b*, Fig. 2658.

Fig. 2638.



Ice-Cutter.

Fig. 2639.

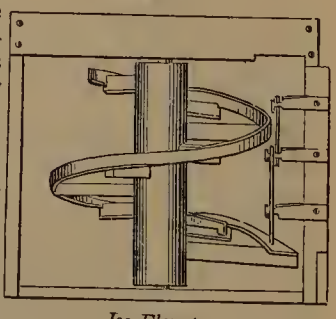


Ice-Cutting Machine.

Ice-el'e-va-tor. A machine for lifting block-ice from one level to another, as from the pond level to the ice-house; in the ice-house from one level to another, and so forth.

There are several kinds. In one, the ice is pushed up a spiral incline by the arms projecting radially from a vertical rotating central post.

Fig. 2640.



Ice-Elevator.

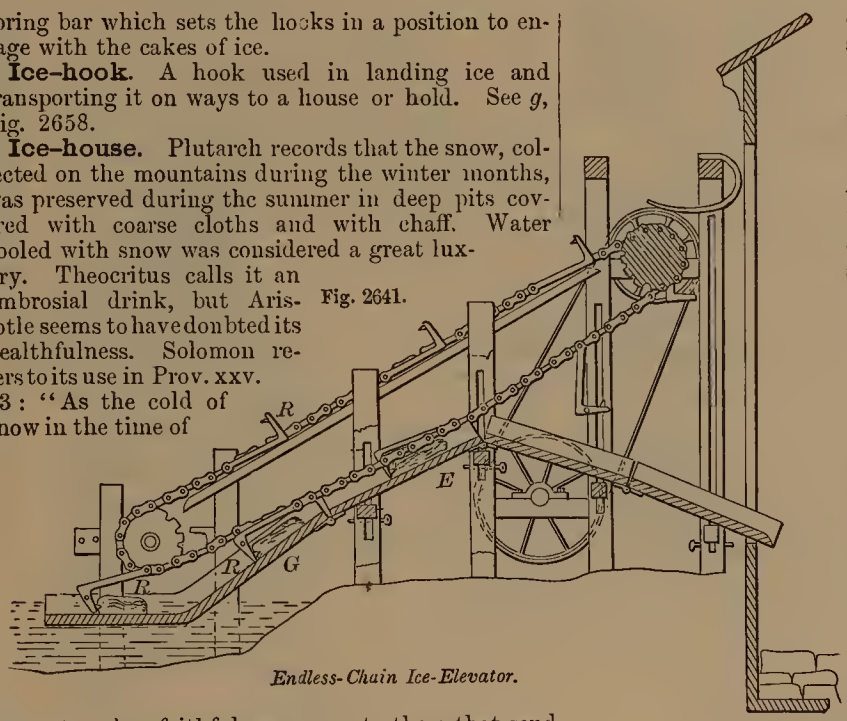
Fig. 2641 is another form, in which an endless chain has a series of hooks *R* which grab the blocks of ice and draw them up the incline *G E*. This is made in sections hinged together, so as to permit either of the upper sections to be placed at different angles to discharge the ice at different elevations. The frame supporting the driving-wheel of the endless chain has a

spring bar which sets the hooks in a position to engage with the cakes of ice.

Ice-hook. A hook used in landing ice and transporting it on ways to a house or hold. See *g*, Fig. 2658.

Ice-house. Plutarch records that the snow, collected on the mountains during the winter months, was preserved during the summer in deep pits covered with coarse cloths and with chaff. Water cooled with snow was considered a great luxury. Theocritus calls it an ambrosial drink, but Aristotle seems to have doubted its healthfulness. Solomon refers to its use in Prov. xxv. 13: "As the cold of snow in the time of harvest, so is a faithful messenger to them that send him; for he refresheth the soul of his master."

Fig. 2641.



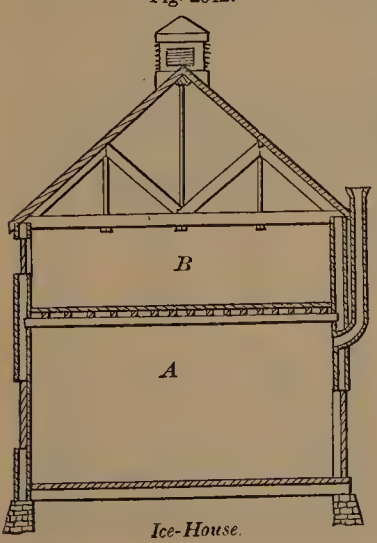
Endless-Chain Ice-Elevator.

When Alexander the Great besieged Patra, he caused thirty trenches to be dug and filled with snow, which was covered with oak branches, and kept a long time.

In Portugal, "snow is collected in a deep gulley, and grass or green sods, covered with sheep-dung, is thrown over it, and under these it is so well preserved that the whole summer through it is sent the distance of sixty Spanish miles to Lisbon"; at least, such was the case in the last century.

In Southern Europe and Asia Minor it may be observed that snow is, and always has been, used instead of ice, being more easily attainable from the summits of the mountains, while ice must be either imported or made artificially. The Appenines, the Sierra Nevada, and other mountains of South Europe, yield an inexhaustible supply in winter in regions where snow seldom or never falls on the plains below, and a very slight protection from the heats of summer suffices to preserve it at considerable elevations above the sea, where the thermometer never ranges very high.

Fig. 2642.



Ice-House.

At least one natural ice-house has been discovered on Mount Etna, where a vast deposit of snow, covered by a mass of ashes and lava, has been preserved for untold ages.

The highest natural temperature authentically recorded was at Bagdad, in 1819, when the themometer in the shade indicated 120° Fah. On the west coast of Africa the heat is nearly as great. The men employed in the English expedition to Abyssinia think that Aden is the hottest hole on earth.

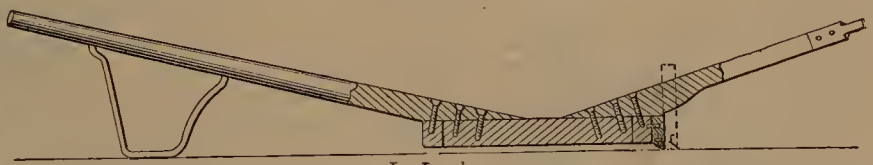
Burckhardt, in Egypt, and Humboldt, in South America, observed 117° Fah. in the shade.

About −70° is the lowest temperature observed by our Arctic navigators. Natterer, a German chemist, obtained −220° Fah. Faraday obtained −166° Fah. Neither succeeded in freezing pure alcohol or ether.

Fig. 2642 is a sectional view of an ice-house for brewers and butchers. It has an ice-chamber *B* and cooling-vault *A*, provided with one or more ventilators *I*.

Ice-lev'el-er. An implement for leveling the surface of pond ice. It has an oblong frame, upon the front side of which is affixed a cutting-edge of steel. From the forward end a tongue projects, and from the rear a guiding-pole with a bent knee, composed of a metallic rod that runs upon the ice. A wide board is adjusted to the front side of the frame for removing snow.

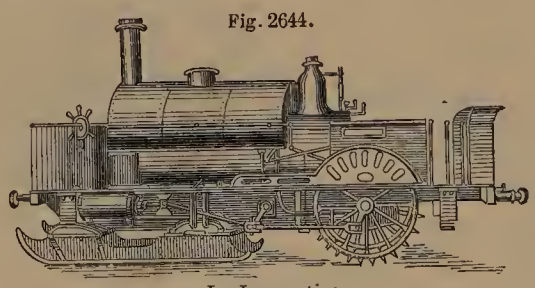
Fig. 2643.



Ice-Leveler.

Ice-lo-co-mo'tive. A traction engine for running on ice; one constructed by Messrs. Neilson of Glasgow, and employed for conveying passengers and freight between St. Petersburg and Cronstadt, has two driving-wheels five feet in diameter and

Fig. 2644.



Ice-Locomotive.

studded with spikes. The front part rests on a sledge, which is swiveled and may be turned by the wheel, which has an endless screw working a pinion that turns a segment rack attached to the sled-body. The cylinders are 10 inches in diameter and

22 inches stroke. The weight of the engine is 12 tons, and it attains a speed of 18 miles an hour.

Ice-mak'ing. Evaporation, radiation, liquefaction, and sudden reduction of pressure, are the causes by which the temperature of a body may be depressed.

Class 1. Vaporization.

This includes those processes which depend upon the vaporization of water, ether, ammonia, benzole, etc., which, in assuming the vaporous form, change sensible heat to latent, extracting it from the objects most convenient thereto, — in this case a reservoir of water whose contents are thereby congealed.

In this class are the atomizers or spray apparatus.

One form of this machine is founded upon the old practice in Hindostan, of cooling water by the evaporation from the outer surface of porous vessels through which the contents percolate. A part is thus sacrificed in cooling the remainder, the water in its evaporation rendering latent the heat abstracted from the contents of the jar. The extent to which this process is carried determines whether the water is cooled to the freezing-point or not.

A modification of this device is found in wrapping a non-porous jar or other vessel with a bibulous covering, which is kept wet and subjected to a draft of air. The contents of the vessel part with their sensible heat in furnishing the heat required by the evaporation of the water in the envelope.

"Protagorus, relating the voyage of King Antiochus down the river Nile, says: 'They expose the water in large earthen ewers on the top of the house, and two slaves are kept sprinkling the vessels with water the whole night; and at daybreak they bring them down and immerse the ewers in water, which is used without snow, as it is cool enough.'" — *Deipnosophists.*

The opinion prevailed among the ancients that water previously boiled or heated was more readily cooled, and in Egypt and other warm countries earthen vessels filled with boiled or heated water were exposed to the air during the night, and in the morning placed in a pit or cellar and bound around with fresh or green plants which were moistened with water, and preserved their contents cool throughout the whole day. In the countries of Southern Asia a similar opinion and practice still prevails.

So far, the conditions of evaporation have been the exposure of water in an atmosphere not saturated with moisture and preferably to air in motion. It may also be added that an artificial motion by fans may be made to replace the lack of natural motion by wind or draft. This accelerates the operation as bringing a larger amount of air in contact with the evaporative surface, and also brushing away the saturated atmosphere immediately adjacent.

Under a pressure less than that of the atmosphere, vaporization takes place at a lower temperature. Were two thirds of the atmospheric pressure removed, water would boil at ordinary summer heat. A vessel of water placed under the receiver of an air-pump, which is then exhausted of air, speedily enters into ebullition; but, unless the machine is kept constantly in action, the vapor which is thus formed will restore very promptly the pressure upon the surface which has been removed by the exhaustion. If, however, the pump be powerful enough to carry off the vapor as fast as it is formed, and be steadily worked, the heat which the rising vapor withdraws from the water will presently reduce the temperature to the freezing-point, and the liquid will be converted into ice.

In 1755, Dr. Cullen discovered that removing the pressure of air facilitated evaporation to a degree which enabled him to freeze water even in summer.

In 1777, Mr. Nairne discovered that introducing sulphuric acid into an exhausted receiver absorbed an aqueous vapor from and thereby dried rarefied air; and by an arrangement on these principles, in 1810, by which he got rid of the vapor that rose from the water, he prevented its forming a permanent atmosphere, so as to prevent the continuance of the operation. Professor Leslie succeeded in freezing quantities of water from 1 to 1½ pounds in weight, though he could not effect the congelation of much larger quantities. This method of promoting evaporation John Vallance, in 1824, improved by removing the atmospheric pressure, which enabled him to carry off the vapor from large surfaces of water and consequently freeze large quantities of ice.

The Parisian restaurants have decanters (*carafes frappées*) filled with water frozen by placing them in shallow tanks of sea-water, each of which is provided with a copper reservoir connected with a receiver filled with ether. The air is exhausted from the reservoirs by an air-pump worked by steam, vaporizing the ether and reducing the temperature of the sea-water and that in the decanters below the freezing-point. The water in the decanters usually remains liquid until stirred with a glass rod, when it immediately congeals.

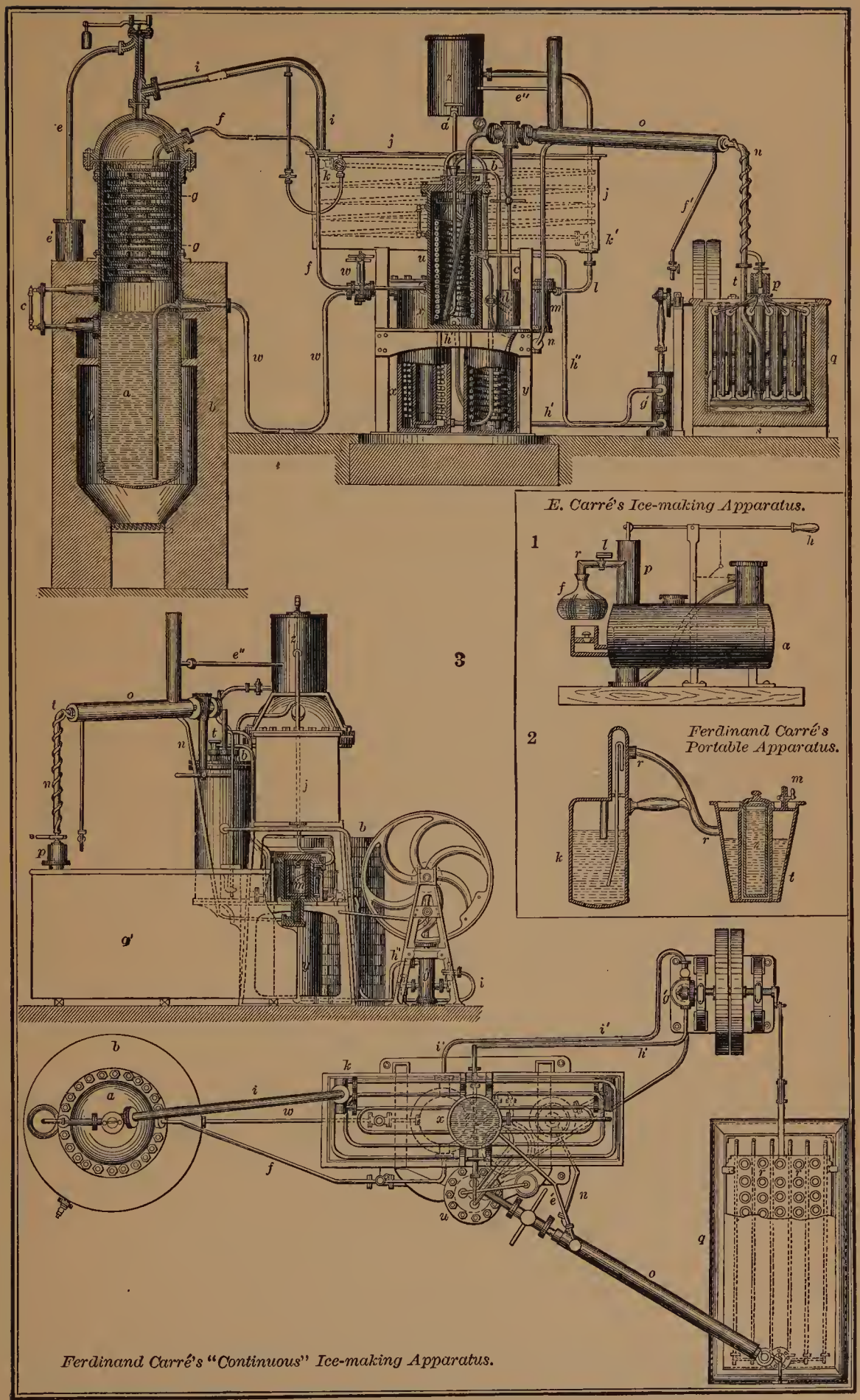
Edmond Carré's sulphuric-acid freezing-apparatus is upon this principle (shown at 1, Plate XXVI.), and is used to produce the *carafes frappées* (frozen decanters) so frequently seen in Paris. It consists of a large vessel, resembling the boiler of a steam-engine, which is designed to contain the concentrated sulphuric acid; of an air-pump with tube connections to be adapted to the wide mouths of the *carafes*, and of a mechanism by which the lever of the air-pump is made to keep the acid in continual agitation. The great volume of the acid renders the loss of absorptive power by dilution very slow, and the constant agitation prevents the formation of a superficial dilute stratum, which would interfere materially with the success.

In the drawing, *a* is the reservoir of sulphuric acid; *f*, a *carafe* of water connected by the tube *r* with the apparatus, and having a stop-cock at *l*. *p* is the barrel of the pump and *h* its lever, which also agitates the oscillator, shown in dotted lines.

We have considered in regular sequence the cooling of water by the access of air under natural conditions; the acceleration of the operation by artificial draft; the facilitating of the operation by the lessening of the atmospheric pressure; the absorption of the evolved vapor by sulphuric acid. We have now to consider the use of materials more volatile than water, notably ether and ammonia, but common alcohol, ether, methylic ether or alcohol, sulphurous or carbonic acid, bisulphide of carbon, gasoline, etc., have each been used.

Liquids.	Boiling-Point Fah.	Latent Heat of Vapor.	Tension of Vapors.
Water	212	966.6	0.623
Alcohol	173.5	376	1.60
Methylic alcohol	119.7	475	1.11
Ether	98	164.4	2.58

In Ferdinand Carré's apparatus the efficient cause producing cold is evaporation, but the liquid employed is ammonia, a substance which is not only much more volatile than water, but, under ordinary atmospheric pressure, is indeed permanently gaseous. Gaseous ammonia is liquefied by a pressure of 8½ atmospheres at a temperature of 68° Fah., or of 10 atmospheres at 77°, the pressure required rising very



CARRÉ'S ICE-MAKING MACHINES.

PLATE XXVI.

See page 1164.

rapidly with the temperature. To liquefy it by cold requires a very low temperature (−65.5 Cent.), and as its latent heat is great it would become a valuable agent for the purpose of producing cold if its vapor could be removed. To do this with economy it must be saved and recondensed. This may be done mechanically by a pump, but with much greater advantage by water, which has the property of absorbing ammoniacal gas in great volume and with singular rapidity. This fact was first illustrated by Faraday in 1823. He used a bent glass tube, containing at one end a portion of chloride of silver saturated with ammonia at 60° Fah. or lower, and hermetically sealed after the air had been expelled by slightly warming the compound. If the chloride be heated to 100° Fah., the ammonia expelled, and the other end of the tube plunged in a cold bath, the gas becomes liquefied. If now the end containing the compound be plunged in a refrigeratory and the other in water, the liquid ammonia will commence boiling, the chloride will reabsorb the vapor as fast as produced, and by the rapid evaporation the water around the tube will be converted into ice.

For economic reasons (see Professor Barnard's Report on the French Exposition, page 369) water is to be preferred to chloride of silver. Water absorbs at moderate temperature 700 times its own volume of ammoniacal gas, a volume capable of producing a quantity of liquid ammonia equal to two thirds the bulk and one half the weight of its own volume, and capable of converting into ice more than three times its own bulk. On the contrary, a given quantity of chloride of silver will produce only a thirtieth part of its bulk of liquid ammonia, and a fifth part of its bulk of ice at 32° Fah.

F. Carré's intermittent apparatus (2, Plate XXVI.) is similar in its operation to the Faraday experiment, aq. amm. being substituted for the Ag., Cl. + ammonia. In the engraving, *k* is the boiler containing the liquor ammonia, and connecting by the pipe *r r* with the refrigerator *t*, which has a well in which is a pan containing the water *z* to be frozen. The boiler *k* is placed over a portable furnace, and the apparatus purged of air, which is driven by the evolved gas out at the stop-cock *m*. This being closed, and the refrigerator immersed in a tank of cool water, the temperature of the aqua ammonia is raised to 130° or 140° Cent., at which heat the ammonia is expelled and is condensed in a liquid form in the refrigerator *t*. The boiler *k* being now removed from the furnace and placed in the water-bath, the temperature of the water in the boiler will fall and the power of the water to dissolve ammonia will be restored. The gas will be rapidly re-dissolved, reducing the pressure, as the liquid ammonia will evaporate with corresponding rapidity, drawing for its latent heat upon the sensible heat of the water to be frozen. The result will be the complete evaporation of the liquefied ammonia and the restoration of an aqueous solution, in the boiler, of the original strength. Between the ice-pan and the well is a body of alcohol which will not freeze, but will act as a conductor. During the refrigerating, the vessel *t* has a non-conducting envelope.

Ferd. Carré's continuous process (3, Plate XXVI.), like the intermittent of Edmond Carré, depends also for its efficacy upon the evaporation of liquid ammonia. In each process the liquefaction is effected in substantially the same way. Aqua ammonia is introduced into a boiler, and the gas is expelled by heat into a condenser; but in order that the process may not be arrested by the exhaustion of the solution, the impoverished liquid is gradually withdrawn from the bottom of the boiler, while a corresponding volume of a fresh and strong solution is constantly flowing in at the top. The condensation is produced by the united effect of cold and pressure. From the condenser, the ammonia in a liquid state passes on to a refrigerator, in which are placed vessels containing the water to be frozen; and as the boiler and the condenser keep up an unfailing supply of the liquid, so the refrigerator will continue to freeze successive masses, so long as the proper temperature is maintained in the boiler. The ammoniacal vapor which leaves the refrigerator is re-dissolved to form the rich solution which is to supply the boiler; and the water of solution is the same which was previously withdrawn exhausted from the boiler itself. Thus, as there is nothing added to the contents of the apparatus, and as there is no escape of any part of them by leakage or otherwise, the same materials go on indefinitely producing a uniform effect.

a is the boiler, exposed to the heat of the furnace *b*; *c* is an indicator to show the level of the liquid; *i* is a tube conducting gas to the liquefier *j*; the vertical pipe above the branch *i* leads to a safety-valve, and any escaping gas passes by pipe *e* to the water-tank *e′*, where it is absorbed. *f* is a tube which brings back to the boiler saturated solution of ammonia from the absorbing apparatus *u u*; this solution passes downward, trickling through the perforated trays *g*, while the ascending gas rises in a sinuous course alternately around the edge of one tray and through a central hole in the next, and so on. This condenses and carries back the watery vapor which accompanies the gas.

The gas passes by tube *i* to the liquefier *j*, passing through a box *k* and a congeries of zigzag and spiral tubes in a bath of cold water constantly renewed from reservoir *z*, which also supplies other parts of the apparatus. The congeries of tubes terminates in another box *k′*, and the ammonia is by this time in a liquid state under the pressure of 10 atmospheres, which is constantly maintained in the boiler. In the liquid state the ammonia passes by the pipe *l* to the efflux regulator *m*, which is the dividing barrier between the part of the machine in which a regular pressure of 10 atmospheres is maintained and the following part where the pressure does not exceed 1½ atmospheres. The regulating device is a floating cup which opens or closes a hole of influx.

The liquid passes from the regulator *m* by pipe *n* to the distributor *p*, the pipe *n* being wound spirally around the tube *t*, through which the vaporized ammonia is returning from the refrigerator *q q*; the vapors serving to reduce the temperature of the liquid in *n* before it reaches the refrigerator.

The refrigerator itself consists of a number of zigzag or spiral tubes — in the apparatus here represented, six in all — immersed in a tank constructed of non-conducting substances. These zigzags return upon themselves six times, forming so many partitions in the tank, between which vessels containing the substances to be subjected to cold may be placed. Each one of the six zigzags receives an equal supply of the liquid ammonia from the distributor. The small tubes conveying this supply are shown at *p*. The vessels *r* to be refrigerated are sustained on a carriage, which is slid back and forth by the same power that works the pump *g′* by which the re-saturated solution of ammonia is returned to the boiler. The space in the tank surrounding the zigzags and the water-vessels *r* is filled with an uncongealable liquid, such as alcohol or a solution of chloride of calcium. The ammonia in the zigzags *q* discharges in a vaporized form into the *collector s* and passes through the tube *t* to the cylinder *u*, where it extends nearly to the bottom of the vessel, and there

discharges the gas into the water which has been brought from the bottom of the boiler *a*, and partially fills the cylinder *u*. From this water the ammonia has been nearly exhausted, and it therefore greedily absorbs the gas ejected into it by pipe *t*. On the left of vessel *u* is a water-level indicator.

Within the vessel *u* is a worm which receives water by pipe *a'* from the elevated reservoir *z* ; after passing to the bottom of the spiral the pipe curves upward and then (marked *b*) descends nearly to the bottom of the vessel *y*, where it discharges.

The water from the boiler *a* passes by pipes *w w* to the coolers *x y* before reaching the vessel *u*, where it re-absorbs ammonia. Between the boiler *a* and the vessel *u* the water is cooled so as to fit it for absorbing gas more freely. The pressure in the boiler is sufficient to expel it when the stop-cock *w* is opened. The vessel *x* is formed of two concentric cylinders, between which are two spiral tubes formed of the pipe *w* continued, and these spirals are immersed in a liquid which fills the annular space between the cylinders and is the reconstituted ammoniacal solution on its way from the absorber *u* to the boiler *a*. The water from the boiler is hot and that from the absorber is cold, and the two to some extent exchange temperatures to mutual advantage, and with additional effect in that they circulate in opposite directions, the liquid from the absorber entering at the bottom and ascending, while the heated water from the boiler enters at the top and descends. From *x* the water in the spiral is conveyed in the pipe *w*, still continued in a single spiral ascending in the vessel *y*, and continued farther in a pipe *w* alongside of the absorber *u*, into which it discharges into a sieve *v* and from which it descends in a shower.

The exhausted solution from the boiler *a* flows freely, as has been said, from the boiler, by pipe *w*, to the absorber *u*, passing the coolers *x y* as described, but it requires some power to force the reconstituted solution back from the absorber *u* through the pipe *f* to the boiler. This power is a pump *g'* driven by a steam-engine or other motor, and taking the saturated solution from the absorber by pipe *h'* and discharging it by pipe *i'* into the vessel *x*, from whence it passes by pipe *f* to the dome above the boiler, as described some distance above. Gas finding its way into the pump is discharged into the upper part of *u*. *e''* is a pipe leading to the enveloping tube *o*, from whence water is conducted by *f'* for the use of the ice-vessels *r*. As the water passes through *o* it is cooled by the ascending vapors of ammonia.

In starting the machine, it is first blown through to expel the air. The air escaping from the vessel *u* passes by pipe *e* to the purger *d* and passes beneath the surface of the water therein, which retains any escaping ammonia.

This apparatus requires a large amount of refrigerating water to maintain at the desired temperature the liquefier and the absorbent vessel, and it also involves a consumption of fuel, not only to heat the boiler containing the ammoniacal solution, but also to work the forcing-pump. The pump may be worked by water-power, if such a power is obtainable, or even in small models by hand ; but for an apparatus producing more than one hundred pounds of ice per hour, a motor is indispensable.

It is stated by Mr. Carré that for every pound of coal burned there are produced from eight to twelve pounds of ice, according to the dimensions of the apparatus. To manage the larger forms of the apparatus, the services of two men are required, and a motor also is necessary, capable of driving two hundred and twenty gallons of liquid per hour into the boiler. The pressure in the boiler must be taken, for the purposes of computation, at not less than ten atmospheres ; and as the machines are adequate to the production of five hundred pounds per hour of ice, they will, within the same time, liberate from solution, liquefy, evaporate, and re-dissolve one hundred pounds of pure ammonia.

On the evaporating principle are the water-jars, or *monkeys*, used in tropical countries and the east of Europe. These are merely unglazed earthenware jugs having a small neck and a spout, and suspended in a current of air or in a doorway. The Australian device for the same purpose is a bucket of canvas, nearly waterproof, and having a flannel cover to form a sieve, and a spout below to draw off the water. Evaporation proceeds rapidly from the wet surface. The East Indian *tatta* (Hind. *tattah*, a screen) is a curtain of bamboo placed in front of a window or doorway and kept wet by a trickling stream of water so as to cool the air passing through its meshes into the apartment.

Fig. 2645.

Hindoo Gurglet.

The mode of procuring ice by exposure in shallow, porous vessels, laid on straw and exposed to the night air, is stated to be practiced in India. The small crust of ice is carefully removed and stored in a straw-lined pit, before sunrise. A large plain, unobstructed as much as possible by trees or buildings, is selected for the purpose, in which pits or excavations twenty or thirty feet square and two feet deep are sunk, the floors being covered with dry stalks of corn or sugar-cane. Upon these are placed the water-vessels, constructed of porous earthenware, and not much more than an inch deep. In the morning, if the sky has been clear, the vessels are found to contain thin plates of ice, which are carefully gathered and stored away. This process was successfully imitated in England in the latter part of the last century by Dr. Wells, author of the Essay on Dew ; and soon afterward an attempt was made in France to employ it for the systematic manufacture of ice, but the undertaking proved to be economically a failure.

Many of the modern ice-machines depend upon the conversion of sensible heat into latent by evaporation, liquids which vaporize at low temperatures being selected.

Harrison's Australian machine used ether evaporating into a partial vacuum produced by an air-pump, and instead of acting directly upon the water to be frozen it was made to reduce the temperature of a solution of salt, which does not congeal at the freezing-point of water, and the solution, thus made extremely cold, was then made to pass between cases containing the water, and, by reducing the temperature, secured the requisite congelation of the same. Twining's patent of 1862 is of this class.

Next in sequence may be considered a French invention, in which the freezing agent employed was amylic ether, which is capable of being dissolved by sulphuric acid. The ether being expelled from the acid by heat, under a pressure of several atmospheres, was liquefied, and passed in this condition to a suitable reservoir, from which, by turning a valve or stop-cock, it was allowed to expand and pass through spiral ducts arranged around a cylinder containing the water to be congealed ; the expansion of the fluid to a gaseous condition acting, as in the other ether machines, to abstract the heat from the water and freeze the same. After having thus accomplished its work, the ether passed to vessels of sulphuric

acid by which it was absorbed, to be expelled therefrom by heat on a repetition of the process.

Twining's apparatus, patented in the United States, November 8, 1853, and subsequently extended for seven years, embraces an exhaust vessel, a pump, and a condensing vessel or "restorer." The water to be frozen is placed in chambers enclosed between thin metallic pipes, plates, or partitions, through which the vapor of a volatile liquid, as ether, sulphide of carbon, etc., is drawn by an air-pump. The vapor is condensed in a coil of pipe surrounded by cold water, and is returned to the reservoir from whence the liquid originally came. Four different modes of applying this principle, substantially the same but varying in details, are specified in the patent.

In Siebe's apparatus an air-pump is employed to vaporize the ether, the vapor of which is then conveyed into the refrigerator, which is surrounded with strong brine. The water to be made into ice is put in metallic troughs, and the brine surrounding them is, by means of the exhaustive process above referred to, cooled down to from 10° to 18° Fah., freezing the water to a depth determined by the time it is subjected to the process.

In Van der Weyde's machine are employed an exhaust and force pump, a cooling coil, and two refrigerators, which act as reservoirs for the condensed liquid. Naphtha, gasoline, rhigoline, or chimogene, are preferred. These are evaporated by an air-pump and forced through a freezer, in which are vessels containing water, surrounded by enclosing vessels filled with glycerine, the outside being surrounded by cryogene. The evaporation of the cryogene causes the refrigeration of the water to a sufficient extent to crystallize it; that is, form it into ice.

Reece's apparatus operates substantially on the Carré principle. The ammoniacal gas employed passes under considerable tension from the refrigerator into a cylinder having a slide valve, entry and exhaust ports, similar to those of a high-pressure engine, so that the gas is utilized to drive the pumps of the apparatus. From the cylinder it passes to the absorber and is returned to the reservoir.

Seely employs anhydrous ammonia. The generators are filled, or partially so, with dry, pulverized chloride of calcium. One of the generators is heated by steam coils, the generated gas passing through the condenser, evaporating in the refrigerator, and is finally absorbed by the dry chloride in the other receiver, to which heat is then applied in its turn, the other reservoir now becoming the condenser.

In Johnston and Whitelaw's, the liquid, bisulphide of carbon, after being vaporized is, with the air forced in by the air-pump, conducted through chambers containing oil, which absorbs the greater part of the moisture of the gas, the moisture of the air being taken up by chloride of calcium, in a pipe leading to the air-pump. The freezing arrangements are similar to those generally employed in machines of this class.

In Charles Tellier's machine, the liquid employed is methylic ether in a volatile state, not requiring to be subjected to heat. It comprises a congealer, compressing-pump, condensing-coil, and reservoir. The congealer consists of five or more receivers of a flat form connected by tubes. The apparatus is placed in a tank containing the water to be congealed. The fluid from the reservoir passes to the congealer, and the vapor exhausted therefrom by the air-pump is conveyed back to the reservoir through a worm.

The novelty of this apparatus consists in freezing the water by immediate contact with metallic plates forming a closed chamber.

For use on shipboard, the congealer is provided with four outlets terminating in a trap. Late attempts at transportation, on shipboard, of fresh meat in ice, from Australia, Buenos Ayres, and Texas to European and United States ports, have given a fillip to this class of machinery.

2. *Radiation.* This does not affect the subject from a mechanical point of view, and we therefore dismiss it.

Class 3. Liquefaction.

Machines and apparatus for icing cream, custard, lemonade, etc., may be classed under this head, and generally operate by means of a frigorific composition of pounded ice and chloride of sodium, in a vessel which surrounds the chamber in which the article to be frozen is placed. The tub containing the ice and salt is of wood, a poor conductor of caloric; and as the ice in liquefaction converts a large quantity of sensible heat into latent, the heat of the cream is carried off to supply the demand of the melting ice, and the cream becomes frozen. When ice or snow is not available, the combination of certain chemicals may produce the same result. The cream is stirred to constantly expose fresh material to the sides of the vessel exposed to the cooling compound. See tables below. See also ICE-CREAM FREEZER.

The use of saltpeter for cooling liquids was known at a remote period in India. It was probably used anciently as it was, in more modern times, in Rome. "The wine to be cooled was put in a long-necked bottle, which was immersed in another vessel filled with cold water; saltpeter was then gradually thrown into the water, and while it was dissolving a quick rotary motion was imparted to the bottle."

Freezing water by a mixture of snow or ice and saltpeter is first mentioned by Tancredus, a physician of Naples, 1607, who says that, by means of it, a tumbler of water may be converted into a block of solid ice. Santorio, in 1626, speaks of freezing wine by a mixture of snow and common salt.

Orosius (King Alfred's version), about A. D. 400, wrote: "And there is among the Esthonians a tribe that can produce cold, and therefore the dead in whom they produce that cold lie so long there and do not putrefy; and if any one sets two vessels full of ale or water, they contrive that one shall be frozen, be it summer or be it winter."

Freezing-Mixtures.

	Thermometer sinks.		Degrees of Fall.
	From	To	
With Ice.		Degs.	
Snow or pounded ice, 2 parts; muriate of soda, 1 part		— 5	
Snow, 5; mur. soda, 2; mur. ammonia, 1		—12	
Snow, 24; mur. soda, 10; mur. ammonia, 5; nitrate of potash, 5		—18	
Snow, 12; mur. soda, 5; nit. amm, 5		—25	
Snow, 3; dilute sulphuric acid, 2	+32	—23	55
Snow, 8; muriatic acid, 5	+32	—27	59
Snow, 7; dilute nitric acid, 4	+32	—30	62
Snow, 4; mur. of lime, 5	+32	—40	72
Snow, 2; crystallized mur. lime, 3	+32	—50	82
Snow, 3; potash, 4	+32	—51	83
Without Ice.			
Mur. amm., 5; nit. pot., 5; water, 16	+50	+10	40
Nit. amm., 1; water, 1	+50	+ 4	46
Mur. amm., 5; nit. pot., 5; sulph. soda, 8; water, 16	+50	+ 4	46
Nit. amm., 1; carb. amm., 1; water, 1	+50	— 7	57
Sulph. soda, 3; dilute nit. acid, 2	+50	— 3	53
Sulph. soda, 6; mur. amm., 4; nit. pot., 2; dilute nit. acid, 4	+50	—10	60
Sulph. soda, 6, nit. amm., 5; dilute nit. acid, 4	+50	—14	64
Phosphate of soda, 9; dilute nit. acid, 4	+50	—12	62
Sulph. soda, 8; mur. acid, 5	+50	0°	50
Sulph. soda, 5: dilute sulph. acid, 4	+50	+ 3	47
Phos. soda, 9; nit. amm. 6; dil. nit. ac., 4	+50	—21	71

	Thermometer sinks.		Degrees of Fall.
	From	To	
Sulph. soda, 8; mur acid, 5	+50	0°	50
Sulph. soda, 5; dilute sulph. acid, 4	+50	+ 3	47
With Materials previously cooled.			
Phos. soda, 5; nit. amm., 3; dil. nit. ac. 4	0	—34	34
Phos. soda, 3; nit. amm., 2; dilute mixed acid, 4	—34	—50	16
Snow, 3; dilute nit. acid, 2	0	—46	46
Snow, 8; dil. sulph. ac., 3; dil. nit. ac., 3	—10	—56	46
Snow, 1; dilute sulph. acid, 1	—20	—60	40
Snow, 3; mur. lime, 4	+20	—48	68
Snow, 3; mur. lime, 4	+10	—54	64
Snow, 2; mur. lime, 3	—15	—68	53
Snow, 1; cryst. mur. lime, 2	0	—66	66
Snow, 1; cryst. mur. lime, 3	—40	—73	33
Snow, 8; dilute sulph. acid, 10	—68	—91	23

By the evaporation of a mixture of solid carbonic acid and sulphuric ether a temperature of 166 degrees below the freezing-point has been produced. By means of this intense cold, assisted by mechanical pressure, several of the gaseous bodies have been condensed into liquids and in some instances solidified.

Class 4. Reduction of pressure.

Machines in which the absorption of heat from the water is accomplished by the expansion of air or gas, or of a liquid into a gaseous condition.

In this division are one class, the carbonic-acid, ether, and ammonia engines, those materials being used as a convenient fluid for the purpose.

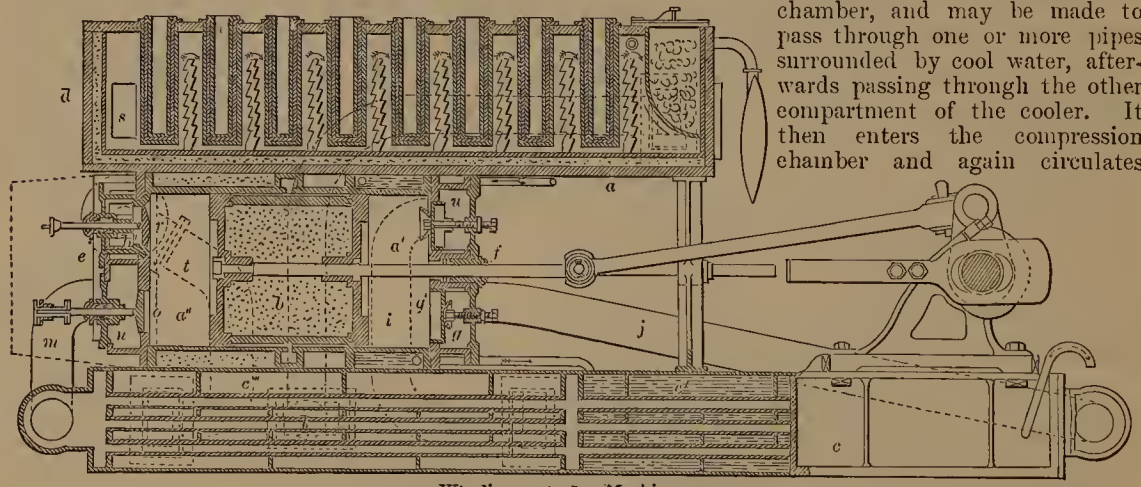
The effect of the rapid dilatation of fluids under a sudden reduction of pressure is strikingly illustrated in the hydraulic machine of Chemnitz, Hungary (see page 28), in which air is highly compressed in a closed reservoir under a column of water. If a stop-cock in this reservoir be suddenly opened, the expanding air rushing out produces a degree of cold sufficient to freeze the drops of water which it brings with it into pellets of ice.

Machines acting by expansion of air-envelope.

Kirk's apparatus (English) was of this character; that is, it absorbed heat by the expansion of air when liberated after compression by suitable mechanical means, the expansion of the air rendering latent the heat in the same manner as the expansion or vaporization of the ether or equivalent fluids in the cases hereinbefore described.

Windhausen's machine has one or two double-acting cylinders with pistons. In case a single cylinder is employed, the air is condensed on one side of the piston and expanded on the other. When two cylinders are used one serves as a condenser and the other serves to expand the air. From the condensing chamber the air passes into a cooler having two compartments, in one of which it is cooled by air and in the other by a constant flow of cool water. From the cooler it passes into the expansion chamber, whence it escapes through a temperature regulator into the refrigerator, in which the vessels containing the water are placed. By means of this regulator a portion of the air from the expansion chamber may be admitted to one compartment of the cooler for the purpose of reducing its temperature. When the air in the refrigerator has become too much heated to be of farther service there, though still at a low temperature, it passes through this compartment of the cooler on its way back to the compression chamber, and may be made to pass through one or more pipes surrounded by cool water, afterwards passing through the other compartment of the cooler. It then enters the compression chamber and again circulates

Fig. 2646.



Windhausen's Ice-Machine.

through the apparatus as before. The operation is thus rendered continuous.

The machine is provided with suitable valves and connections, and may be operated by hand or power.

The operation is as follows: —

During the forward stroke of the piston — that is to say, its movement toward the front cylinder head *f* — the air is compressed in the compressing-chamber *a'*, and by its pressure caused to open the valve and pass out through the compartment *g* of the head and through the pipe *j* to the cooler, in which it passes first through the pipes *c'*, and afterward through the pipes *c''*, and is thereby cooled. From the cooler the compressed air passes through the pipe *m* into the compartment *n* of the back cylinder-head *e*, whence it passes through the valve *o* into the expansion-chamber *a''* of the cylinder during a portion of the stroke, and until the valve *o* is closed, after which the air in the latter chamber expands during the remainder of the stroke. During the whole return or back-stroke of the piston, the expanded and cooled air from the expansion-chamber passes out through the open valve *r* into compartment *b'* of the cylinder-head *e*, and thence to the temperature-regulator, whence a portion of it passes through the pipe *s* to the refrigerator, and a portion through the pipe *t* into the space surrounding the pipes *c''* in the left compartment of the cooler. At the same time the air displaced from the refrigerator by the incoming cold air passes out through the pipe *k* into the aforesaid space of the cooler. The air all passes out from this space of the cooler, through the pipe *i*, into the compartment *u* of the front cylinder-head, whence it is drawn by the

piston, through the inlet-valve into the compression-chamber of the cylinder.

The refrigerator *d* consists of a double-cased rectangular wooden chamber, the space between the casings being filled with loose cotton or other non-conductor of heat. Its cover has rectangular openings for the insertion of metallic cases for containing the vessels in which the water to be frozen is placed. To insure the air coming fully in contact with all parts of the cases, zigzag partitions are placed in the compartments between them. The air in the refrigerator, expanded to atmospheric pressure, abstracts heat from the metallic cases, becoming gradually warmed itself, and is finally, through a pipe *k*, returned to the cooler. A uniform pressure is maintained within the refrigerator by means of an india-rubber bag, which admits or gives out air, according as the pressure is in excess of or below that of the atmosphere.

In Gorrie's apparatus, air is compressed by a double-acting pump into which water is injected on that side of the piston on which condensation is taking place. The condensed air passes through a worm surrounded by cold water to a reservoir, whence it is admitted to an auxiliary pump driven by the expansion of the compressed air, in which it is expanded, cooling a non-congealable fluid in a jacket surrounding the pump-cylinder. This abstracts the heat from the water contained in a reservoir in a chamber above the pump, causing its congelation.

Lowe uses carbonic-acid gas compressed into a liquid state. The apparatus consists of a gas-holder, a pump, a cooler, a dryer filled with chloride of calcium, a condensing coil placed in a tank and surrounded by water, and an expansion or congealing chamber in which are placed the receptacles containing the water to be frozen. The gas is admitted to the pump, where it is liquefied. The heat thus generated is absorbed by the cooler, and the gas is allowed to expand into the refrigerator, where it performs the office of freezing the water.

Tuttle and Lugo. In this apparatus air is compressed and forced by a pump into a tubular chamber, the tubes of which are surrounded by cold water, and thence through a second chamber, the tubes of which are surrounded by a volatile liquid. It next passes into the refrigerating chamber, rising through a volatile liquid as ether, bisulphide of carbon, etc., contained therein; the air and vapor from the liquid fill the interior of this chamber, surrounding the vessels in which the water is contained and congealing it. They are thence conducted through a cooling chamber back to the pump.

A pipe is provided by which the compressed air may be carried directly to the refrigerator.

Lugo and McPherson. The air from a blower is forced through a chamber containing porous material saturated with water, and being there cooled is conducted to a condensing-pump, the upper part of which contains water, serving to keep the pump cool and pack the piston. The piston is driven by the epicycloidal combination of La Hire. From the pump the air passes to a cooler, and thence to a reservoir, from which it is conducted to a large congealing chamber or ice-house, which has non-conducting walls and a track for cars carrying pans of water.

Ice-mark'er. A species of plow for grooving pond ice in the line of the future lines of separation by the saw, or fracture by spades and axes. See *a*, Fig. 2658, ICE-TOOLS.

Ice-pick. (*Domestic.*) An awl-shaped tool to break ice into fragments.

Ice-pitch'er. A metallic pitcher with non-conducting interval between its double sides. In the example, it is supported in a stand in which it may be rotated or tilted forward.

Fig 2647.

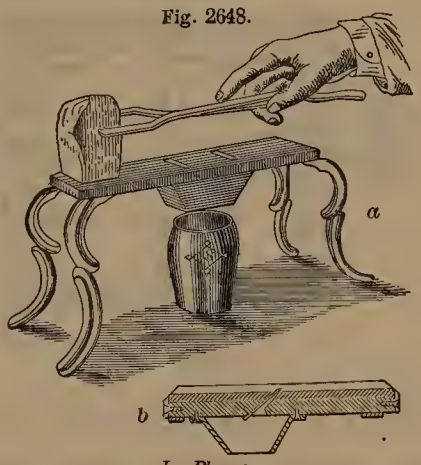
Ice-Pitcher.

Ice-plane. 1. A tool for dressing the surfaces of ice-blocks before stowage in bulk.

2. An instrument for shaving off fragments of ice for cooling drinks. *a* is placed on a stand, *b* is of similar construction but not mounted.

Ice-plow. A tool for cutting grooves in pond ice, to facilitate its fracture or cleavage into square blocks for landing, transportation, and stowage.

Fig. 2648.

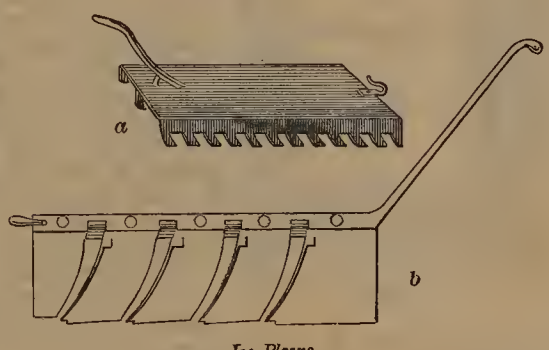


Ice-Planes.

The upper figure *a* is a frame which cuts three parallel grooves in moderately thick ice.

The lower figure *b* has five consecutive shares,

Fig. 2649.

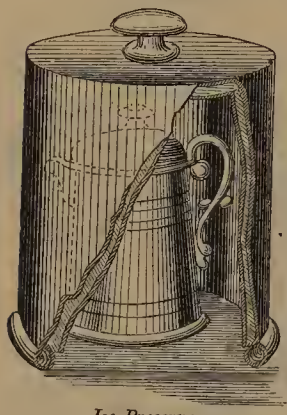


Ice-Plows.

which make and follow in the same groove in cutting deep ice. See also *a b*, Fig. 2658.

Ice-pre-serv'er. A cover for an ice-pitcher to economize the ice by keeping the warm air from contact with the outside of the pitcher. It is made of straw, woolen, or cotton felt, and lined within and covered without with flannel. The top is made of wood, to give form to the cylinder, and has a

Fig. 2650.



Ice-Preserver.

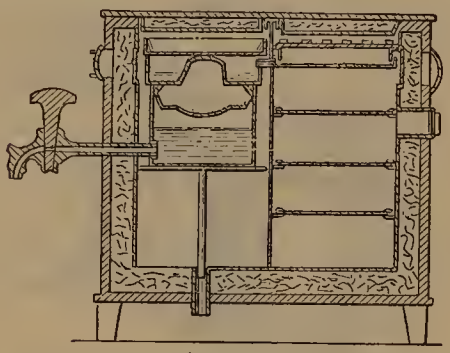
handle for convenience in raising it.

Ice-safe. A chest in which provisions are kept cool by the presence of ice.

The box and the cupboard forms are the more usual, and the safe sometimes is made quite ornamental for a dining-room.

In the example (Fig. 2651), the space between the inner metallic case and outer wooden one is filled with pulverized charcoal, and a wooden rack supports the ice. Air-passages connect the ice-chamber to the cooling chamber below. A tube carries the water from the ice-chamber to the filter.

Fig 2651.

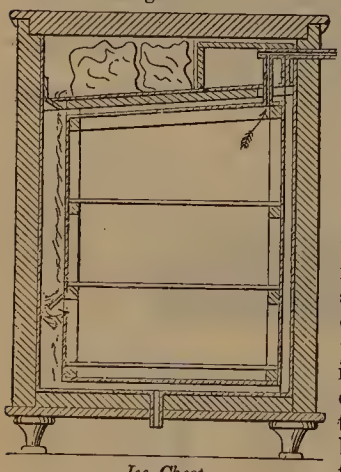


Ice-Safe.

The chambers are ventilated by pipes from the outside.

In the ice-safe Fig. 2652 the ice is on the slanting top of the food-chamber, and the water drips down the back, inducing a current of air which is cooled by contact and caused to circulate through the chamber in the direction of the arrows.

Fig. 2652.



Ice-Chest.

Fig. 2653 has revolving shelves. A removable tube, with a perforated cap at one end and a diaphragm at the other, is fitted in the ice-chamber, which, with the refrigerator chamber, has a removable top of two lids hinged together. Two dead spaces, one inside of the other, surround the sides of the cylinder and the refrigerating space, and a trough with discharge-pipes runs around the outside wall at the bottom.

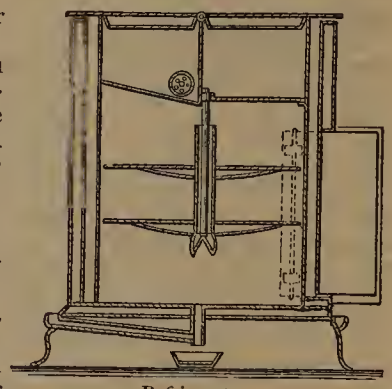
Ice-san'dal. A clog or shoe to be worn over the boot, and having spurs on the sole to prevent slipping on ice. (Fig. 2654.)

Ice-saw. A long saw with a weight at the lower end (beneath the ice), for cutting long kerfs in pond ice, to make a track for vessels, or to form long slices which are broken in blocks for storage.

Ice-saws in the Arctic regions are made of $\frac{5}{8}$ to $\frac{3}{4}$ inch steel blades, 10 to 24 feet long. See *h*, Fig. 2658, ICE-TOOLS.

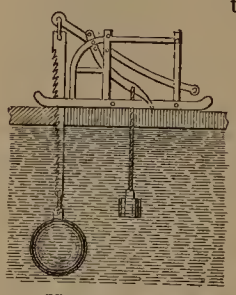
Hood's ice-saw (English) is mounted on a sled, which is advanced a given distance during each cut, by means of a lever-dog. The saw is suspended from the end of a brake-lever, the weight suspended at the lower end giving the effective stroke, while the men at the brakes raise it between cuts.

Fig. 2653.



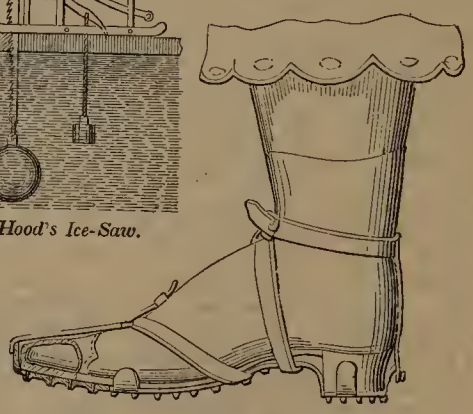
Refrigerator.

Fig. 2655.



Hood's Ice-Saw.

Fig. 2654.



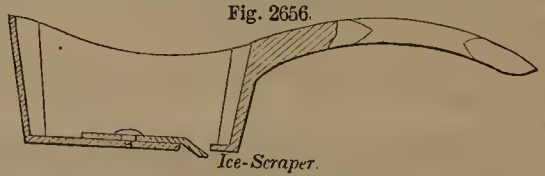
Ice-Sandal.

At each end of the saw is a link or clevis, by which it is attached to the brake-lever and the weight, respectively. The weight is of the shape of a double convex lens, so as to offer as little impediment as may be to its vertical motion in the water below the ice. The propeller is an iron bar having two claws at its lower end, by which it catches a foot-hold on the ice, and at top is a fork which embraces the lever and is suspended therefrom by a transverse pin. A weight is hung to the propeller to keep the toe-calks in contact with the ice. A transverse bar limits the upward throw of the brake-lever.

The saws are used in cutting ice for storage, but their principal use has been in northern latitudes, in cutting passages out of the ice floes and fields, in which vessels have become entangled and frozen up.

Ice-scrap'er. An implement to clean and remove snow from the surface of ice which is to be cut and stored for use.

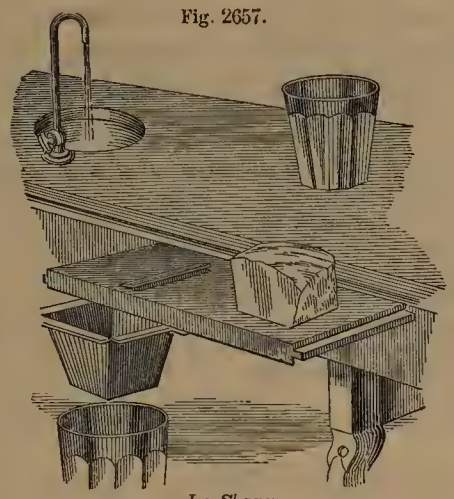
Fig. 2656.



Ice-Scraper.

Ice-shav'er. A device for planing ice to cool a beverage in a tumbler.

Fig. 2657.



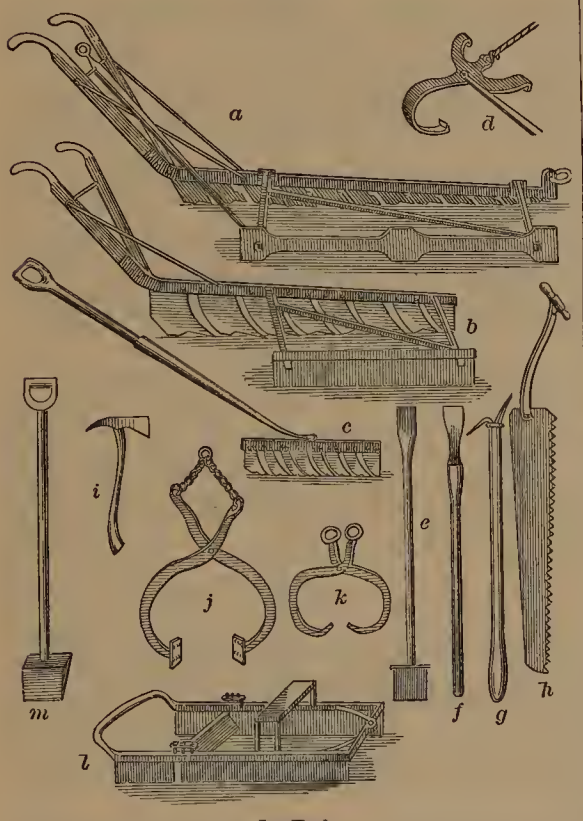
Ice-Shaver.

Ice-spade. A tool for cutting ice. See *m*, Fig. 2658, ICE-TOOLS.

Ice-tongs. Grasping implements for carrying blocks of ice; or, on a small scale, for handling pieces of ice at table. See *j k*, Fig. 2658.

Ice-tools. Fig. 2658 shows an assortment of

Fig. 2658.



Ice-Tools.

cast-steel ice-tools made by Stafford, Holden & Co., of Barre, Vermont: —

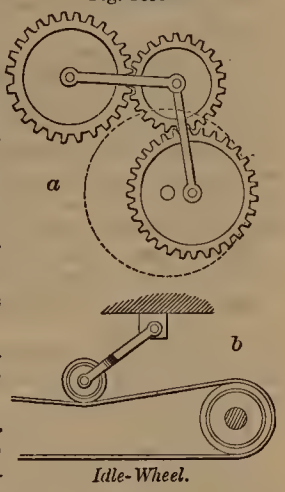
a is a marker.
b, cutter with guide.
c, a hand-cutter.
d, grapple.
e, striking-off bar.
f, chisel-bar.
g, hook and pick.
h, saw.
i, hatchet.
j, hoisting-tongs.
k, landing-tongs.
l, snow-planer.
m, ice-spade.

Ich'no-graph. (*Drawing.*) A ground-plan; an *orthograph* is a front elevation, a *scenograph* a general view.

I'dler. A cog-wheel (as at *a*) placed between two others to communicate the motion of one to the other. By its interposition they are caused to rotate in the same direction, which would be otherwise if they geared directly into each other.

Another description of idle-wheel (as at *b*) is caused to rest upon a belt to tighten it, to perfect its adhesion to the band-wheels over which it runs.

Fig. 2659.



Idle-Wheel.

I'dle-wheel. See IDLER.

Id'wall-stone. A Welsh oil-stone from Snowdon.

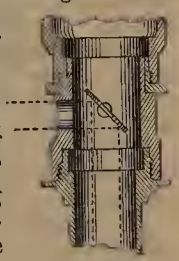
Il-lu'mi-na-ted Clock. This practice appears to have commenced in Glasgow, Scotland, where a clock with two faces supported at the extremity of a projecting bracket was lighted by jets placed above it, the light of which was reflected upon the dials from mirrors placed beneath a carved phœnix which surmounted the clock. The jet was lit by a *flash-pipe*, which consists of a supplementary pipe pierced with a row of small holes throughout its length. Gas issuing from each of these is lit, and forms a communication between the match of the lighter and the issuing gas of the burner.

The more usual plan of illuminating clocks is to make a transparent dial-face, having figures thereon which show dark on a light ground. The dial-chamber is illuminated in the ordinary manner. The church-clock of St. Giles, in the Fields, London, was lighted April 23, 1827.

For modes of lighting the gas without climbing to the tower or spire, see GAS-LIGHTING BY ELECTRICITY.

Il-lu'mi-na-tor. A device to throw light upon an object in an optical instrument; such as a lens which condenses light upon an object under observation, or a lamp which throws a pencil of rays upon the micrometer wires in a telescope.

Fig. 2660.



Illuminator.

Beck's *opaque illuminator* for high powers consists of a circular disk of thin glass placed at an angle of 45° in the axis of a microscope, receiving rays from a lateral aperture, and directing them downward upon the object. The *objective* is made its own condenser.

The *white-cloud* illuminator is to transmit a subdued white light, and is sometimes a surface of pounded glass or of plaster of paris.

The *oblique illuminator* is for directing oblique rays upon an object. This is attained by the concave mirror, Amici's prism, etc.

The *black-ground illuminator* places an opaque surface behind the object and illuminates the surface. See SPOT-LENS; PARABOLIC ILLUMINATOR.

To these may be added the various illuminators for opaque objects, and known as CONDENSERS, SIDE-REFLECTORS, PARABOLIC REFLECTORS, LIEBERKUHNS, etc. (which see).

Il-me'ni-um. Symbol, *Il.* One of the rare

metals but little known beyond the laboratory of the chemist.

Im-bow'ment. (*Architecture.*) A vault or arch.

Im'bri-cat-ed. (*Architecture.*) Overlapping; as tiles or shingles on a roof.

Im-i-ta'tion-met'als. See MOCK-GOLD; MOCK-SILVER, etc.

Im-mer'sion-lens. (*Optics.*) An achromatic objective for the microscope, which is used with a drop of water between the front lens and the glass cover of the object examined, to prevent the extreme refraction of the luminous pencils if air is present, as in ordinary microscopical examinations, and which thus secures better definition and longer working distance for the same power.

Im-pa'ges. The horizontal parts of the framework of doors, commonly termed rails.

Im-pe'ri-al. 1. A baggage-case on the top of a traveling-carriage.

2. A roof with a pointed or tent shape.

3. A size of paper, variously quoted as to sizes; paper-makers differ.

Printing-paper, 22 × 32.

Flat writing-paper, 22 × 30.

Blank-book paper, 22 × 30 to 23 × 31.

Im-plu'vi-um. The cistern in the central part of the court or atrium of a Roman house, to receive the rain-water.

Im-pos'ing. The arrangement of pages in a form. When wedging up the *form* in the *chase* the form lies upon the *imposing-stone*, and the various pages are arranged so as to match their fellows on the other side of the sheet, so that when folded the pages shall come in consecutive order.

The *number of pages on one side of the sheet* determines its name, as follows: —

Folio, 2 pages.	Duodecimo (12mo), 12 pages.
Quarto, 4 pages.	
Octavo (8vo), 8 pages.	16mo, 18mo, 24mo, etc.

When perfected, that is, printed on the other side, the sheet has double the number, so that there are 8 pages to a quarto signature, 16 to an octavo, etc.

They are imposed as follows, the illustration showing how the pages appear in the form.

O. F., outer form; I. F., inner form.

18, 24, 32, and 48mo may be imposed in a similar manner, or may be so imposed as to be cut before folding. See Ringwalt's "Dictionary of Printing."

Im-pos'ing-stone. (*Printing.*) A slab on which the type is made up into forms. The *chase* lies on the *stone*, and the *matter* is arranged inside, being keyed up by the *quoins*.

Im'-post. The upper member of a pillar, column, or entablature, upon which an arch or superstructure rests. A *plat-band*.

The upper stone of a pier or abutment, upon which the *springing* or bottom stone of an arch is imposed.

Imp-pole. (*Building.*) A pole serving to support the scaffolding. A scaffolding *imp*.

Im-pres'sion. (*Printing.*) The pressure applied to a sheet in the press. Also the appearance of the sheet, front or back, when it is taken from the press.

Making ready is to prepare press and form for printing. When some lines or letters in a form have been worn longer than the other type, a piece of paper is pasted on the bottom of these lines to raise them to the proper height. This is called an *underlay*.

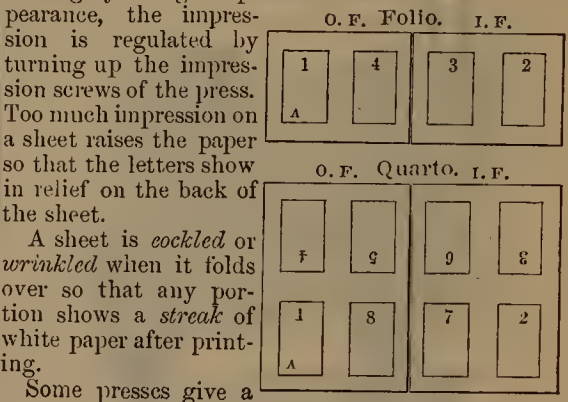
When type or stereotype plates give a *faint impression* in spots, a piece of tissue paper of the size and shape of the spot is pasted upon the *tympan*. This is called an *overlay*. When the whole sheet has a gray or light appearance, the impression is regulated by turning up the impression screws of the press. Too much impression on a sheet raises the paper so that the letters show in relief on the back of the sheet.

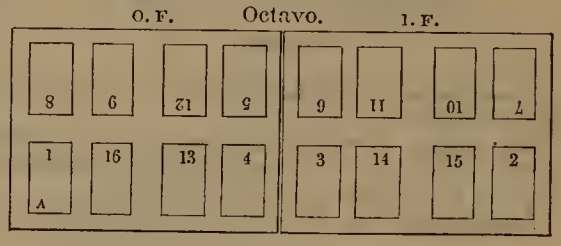
A sheet is *cockled* or *wrinkled* when it folds over so that any portion shows a *streak* of white paper after printing.

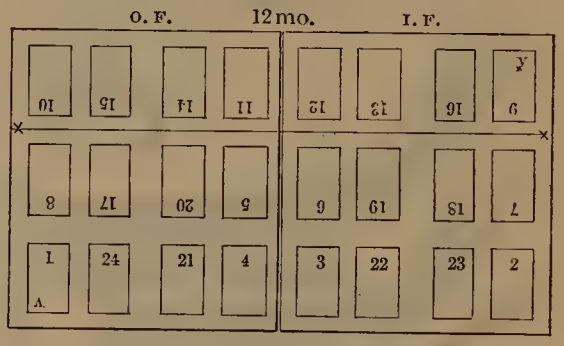
Some presses give a *dwelling* impression by holding the type and paper in contact for some instants. Lithographic presses give a *drawing* impression.

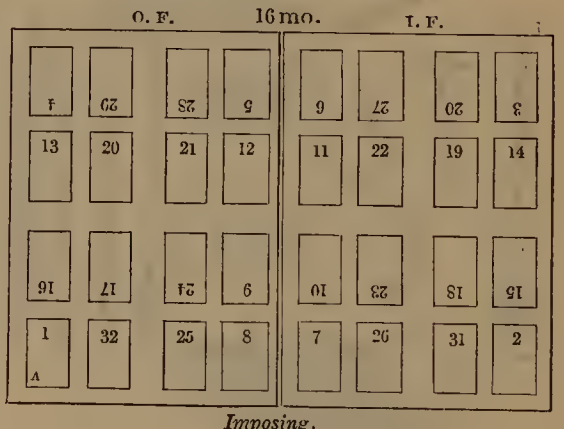
A sheet is *slurred* when it is allowed to slip upon the face of the type after inking. It is *smeared* after printing by handling or folding while *green*, or before the ink is *set*. Dry pressing printed sheets flattens down the impression and fixes the ink, though if pressed while too wet the ink may *offset*. *Monks* and *friars* are black or white blotches which may appear on a sheet from imperfect distribution of ink on the *rollers* or *form*.

Fig. 2661.









Imposing.

Im-pres'sion-cup. (*Dentistry.*) A cup to hold material for taking an impression of the mouth for the purpose of making an artificial denture.

In-and-out-bolt. A *through* bolt. One passing through a ship's planking, the frame, and the knees of the beams.

In-boards. (*Bookbinding.*) The sides covered with paper.

Cut-in-boards: leaves cut after the cover is on.

Out-of-boards signifies that the edges are trimmed before covering.

In-cen'di-a-ry Com'pounds. Greek-fire, said to be the invention of Callinicus of Heliopolis, in Syria, in the seventh century. It was first used upon the Saracens' ships. It was blown out of long tubes of copper, shot out of cross-bows, and projected in other ways. It burned on water, and diffused itself on all sides.

The composition of Greek-fire was kept as a state secret in Constantinople. It is believed that it contained sulphur and nitrate of potash mixed with naphtha. See GREEK-FIRE.

The Arabs had an incendiary composition formed of sulphur, saltpeter, and sulphide of antimony, mixed into a paste with juice of black sycamore, liquid asphaltum, and quicklime.

The French engineer Chevallier, about 1797, invented a compound which would burn under water.

Shells, charged with this or a similar substance, are said to have been found on some of the ships of the French fleet which carried Napoleon and his army to Egypt, and were afterwards taken or destroyed by Nelson at the battle of the Nile.

Rock-fire is one of the best known modern incendiary compositions; it burns slowly, is difficult to extinguish, and is used for setting fire to ships, buildings, etc. For putting in shells it is cast in cylindrical paper cases, having a priming in their axes.

Rock-fire is composed of rosin, 3 parts; sulphur, 4; niter, 10; regulus of antimony, 1; mutton-tallow, 1; turpentine, 1. These are combined by pulverizing the sulphur, niter, and antimony separately, mixing them by hand, and passing them through a sieve; the tallow is melted over a fire, the rosin is then added, next the turpentine, and afterward the other materials; the whole being thoroughly incorporated by stirring with spatulas, and great care being taken to prevent its taking fire. When the composition becomes of a brown color the fire is permitted to go down, and when sufficiently fluid is poured into the paper cases.

Niepce experimented upon the effects of potassium and benzole, and ascertained that ½ gramme of potassium in 300 grammes of benzole would spontaneously ignite on the surface of the water, burning and spreading over a considerable surface. Petroleum may be substituted for benzole. A solution of phosphorus or chloride of sulphur, in sulphuret of carbon, also spontaneously ignites on exposure to the air.

In-cen'di-a-ry-shell. A hollow projectile charged with incendiary composition, and designed for setting fire to buildings, ships, and other objects. Hollow balls, filled with fire, appear to have been among the earliest projectiles used in warfare after the introduction of the Greek-fire, though these were not fired from cannon; but descriptions are given of balls of fire used by the Saracens in Spain, which seem to correspond closely with modern incendiary-shells. The use of incendiary compounds appears to have gradually become obsolete, as we hear little or nothing of their employment until toward the close of the eighteenth century, hot shot being used as a substitute.

About 1797, Chevallier, in France, invented an incendiary compound, which seems to have been tried to a limited extent by the French government, for filling shells. Since then, many inventors have exercised their ingenuity upon this subject, the principal object being to obtain an inextinguishable composition for charging shells, to be ignited either by time-fuse or by percussion.

The only shells of the incendiary kind generally recognized in modern warfare are CARCASSES (which see).

In-cer'tum. A form of masonry made of a facing of square stones of irregular sizes and a filling of rubble. *Rubble-work.* See MASONRY.

Inch. The $\frac{1}{36}$ of a yard; the $\frac{1}{12}$ of a foot. The yard is the standard in England and in North America. See UNIT.

In'cli-na-tion. (*Compass.*) One of the three elements of magnetic force which are registered at the observatories. The other elements are the *declination* and *absolute intensity.*

The *inclination* or *dip* is the vertical angle of a freely suspended needle which it makes with the horizon. It has a general dependence upon the latitude, but varies from local causes. See DIPPING-NEEDLE.

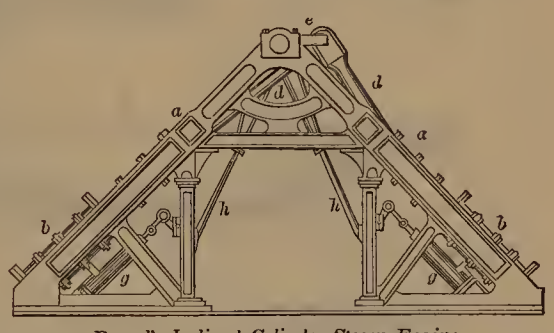
In'clin-a-to'ri-um. The dipping-needle invented by Norman, of London. See DIPPING-NEEDLE, also MAGNETOMETER.

In-clined'-cyl'in-der Steam-en'gine. A form of *direct-action steam-engine*, in which two cylinders are placed in a frame so as to work at an angle to each other, the connecting rods giving motion to the same crank.

It was invented by Brunel, and patented by him in 1822.

a a is a strong triangular frame of cast-iron, within which are fixed the two cylinders *b b*. Mr. Brunel preferred that the angle formed by the axes of the

Fig. 2662.



Brunel's Inclined-Cylinder Steam-Engine.

cylinders should be 102°. *d d* are the connecting rods attached to the crank *e*, which gives motion to the paddle-shaft.

The piston-rods are supported upon rollers, which traverse on guide-plates to preserve their parallel motion during the stroke. In the small cylinders *g g* are piston-valves by which the steam from the boiler is admitted to the alternate ends of the cylinder and allowed to escape from the other end. The action of the piston-valve is regulated by the eccentrics on the paddle-shaft. These eccentrics give motion to the rods *h h*, which, by intermediate levers, operate upon the pistons in the small cylinder.

This is one of the numerous devices intended to obviate the use of the beam in marine engines.

In-clined' Plane. An artificial slope forming an ascent for vehicles ; the climbing passes for pedestrians perhaps hardly deserve the name.

Stevinus, in his work on the principles of equilibrium, 1586, established the fundamental property of the inclined plane, and solved the value of forces acting obliquely. Galileo's treatise on Mechanics appeared a few years later.

In various parts of the old countries of Europe and Asia are the remains of vast engineering works on the main routes of travel and conquest.

It is supposed that the grade on the great canal of Sesostris (1500 B. C.), which united the Red Sea and the Nile, was overcome by a sluice ; probably an inclined plane down which the water ran. The difference in level is but slight, and perhaps on account of the fear of the contamination of the fresh water of the river by the salt water of the sea, it may really have been an inclined plane like that which crossed the Isthmus of Corinth some centuries afterward. The sluice preceded the lock in Europe (see CANAL), and was probably used also in the grand canal of China, built in the ninth century A. D. The canal lock was invented in Italy in the fourteenth century.

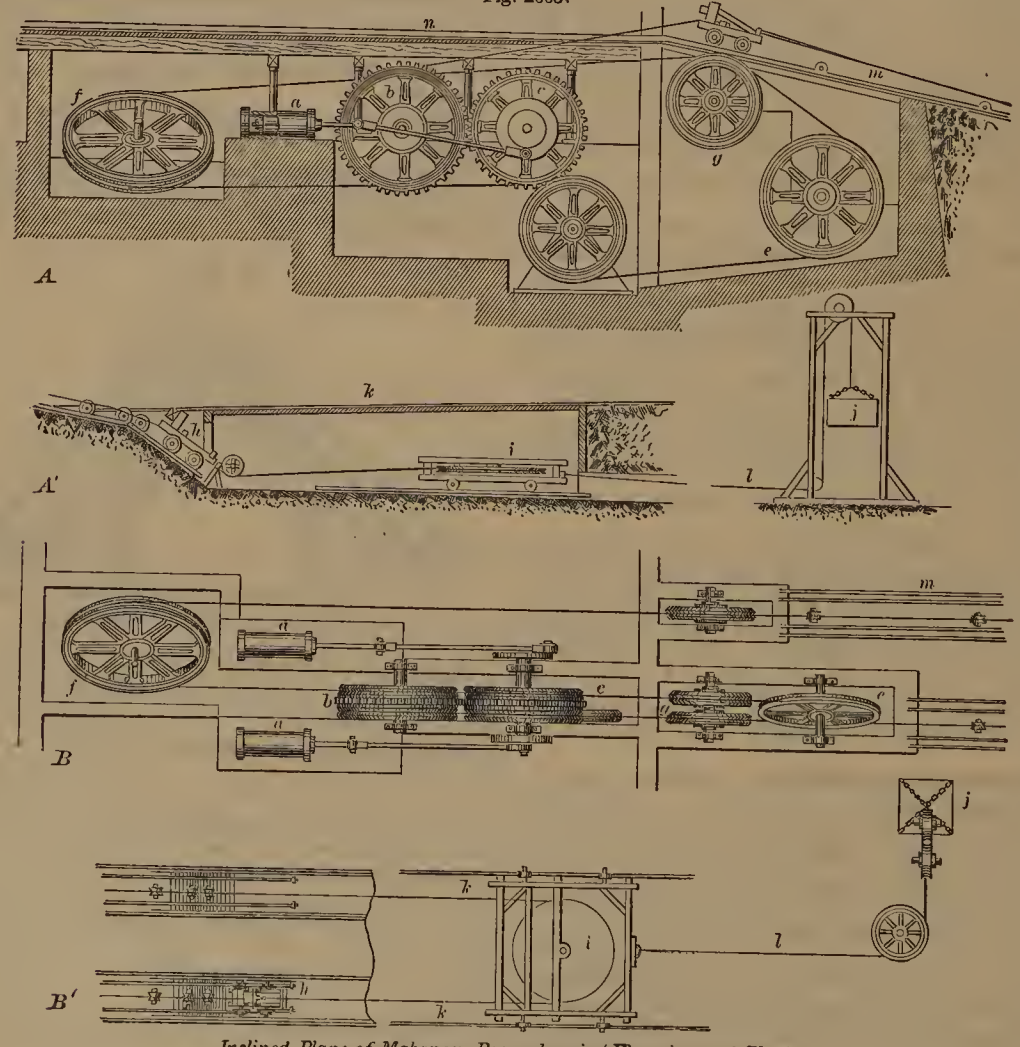
On the Mount Cenis Railroad, which crossed between Savoy and Italy previous to the completion of the tunnel, the elevation is overcome by a series of inclined planes, with mechanical devices to cause a positive grip upon the rails, instead of depending upon frictional contact for the tractile effect of the motor. The railway tunnel has superseded the mountain road.

On the old line of the Pennsylvania Railroad by Hollidaysburg, the reader may have noticed and admired the inclined planes by which the summit and several other gradients were ascended ; stationary engines at the summit of each grade hoisting or lowering the cars by means of ropes. The London and Blackwall Railway was operated in a similar manner, though the road was about level.

The Portage Railway formerly occupied a nearly central position on the main line of the Pennsylvania Canal, between Columbia and Pittsburg, and extended from Hollidaysburg, on the eastern base, to Johnstown on the western base of the Alleghany Mountains, a distance of thirty-six miles ; the total rise and fall on the whole length of the line being 2,571.19 feet. Of this hight, 2,007.02 feet were overcome by means of ten inclined planes, and 564.17 feet by the slight inclinations given to the parts of the railway which extend between these planes. The distance from Hollidaysburg to the summit-level is about ten miles, and the hight is 1,398.31 feet. The distance from Johnstown to the same point is about twenty-six miles, and the hight 1,172.88 feet. The hight of the summit-level of the railway above the mean level of the Atlantic is 2,326 feet.

The machinery by which the inclined planes were

Fig. 2663.



Inclined Plane of Mahonoy, Pennsylvania (Elevation and Plan).

worked consists of an endless rope passing round horizontal grooved wheels placed at the head and foot of the planes, which are furnished with a powerful brake for retarding the descent of the trains. The ropes were originally made 7½ inches in circumference, but were afterwards increased to 8 inches to give them a better bite in the grooves of the wheels over which they passed. Two engines of 25-horse power each were placed at the head of the inclined planes, and were used alternately, week about, the duplication being for the purpose of security in case any accident happened to one of them. The traction rope passed around a horizontal grooved wheel driven by the engine.

The planes were laid with a double track of rails, an ascending and a descending car being attached to the respective ends of the rope at the same time. A safety-brake was attached to each car, which was attached by two ropes of smaller size to the endless rope by a hitch or knot.

Locomotives were used on the intervening levels and slight grades.

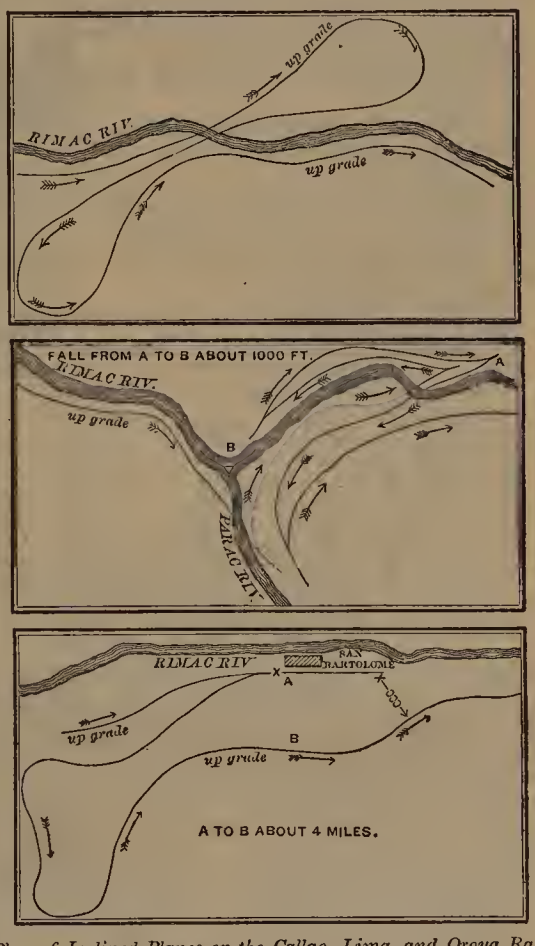
Fig. 2663 shows a side elevation and plan of the inclined plane of Mahonoy, Pennsylvania, up which the cars loaded with coal and other products from the mines of the valley of the Mahonoy are elevated by stationary engines and wire ropes. The length of the incline is about 2,400 feet, and the total elevation about 360 feet. It has two tracks of the usual gage, upon which the wagons ascend and descend alternately. Between each of the tracks are two narrower tracks, with rails about 40 inches apart, and which are traversed by trucks *h*, to which the hoisting rope is attached, and whose duty is to push the wagons traversing the wider track up hill, and also let them down gradually. The wire rope which moves the trucks passes over large pulley-wheels, with grooved faces, one *f* at the top, and the other *i* at the bottom of the plane. The pulley *f* at the top is on a fixed axis, but that at the bottom *i* is on a truck traversing a short track, and held at a certain tension by a rope *l* extending over a pulley on a frame, and with a suspended weight *j* of 3,960 pounds. By this means a regular tension is kept upon the draft-rope, notwithstanding changes of temperature of the wire rope. The same ties support both tracks and the frames of the pulley midway of the tracks which support the wire rope. These pulleys are 50 feet apart, and are from 9 to 14 inches in diameter. The cable is a little over 2 inches in diameter, the lower cable about 1½ inches. The core of the cable is formed of 7 strands, each of which is formed of 7 wires; the exterior surface is 6 strands of 19 wires each. The cable has a spring attachment to the truck. The usual lift is 12 wagons at once. At the foot of the incline the truck runs into a pit below the track, and ascends in the rear of the last car of a train of 10 made up for ascent. In the descent of the empty cars, when the truck runs into the pit, the wagons continue to run by their acquired impetus upon the track *k*, the truck descending on the diving narrow track, as shown at the portion of the figure marked *A'*.

The hoisting apparatus is placed in an underground chamber at the top of the incline, beneath one of the two tracks. It is driven by two horizontal steam-engines *a a*, which turn the large drum *c*, and this is geared to the drums *b*. The drawing cable coming from one of the roads (say the lower one, shown in figures *B B'*), is bent by pulley *g*, and passes over one side of drum *b*, underneath it, and thence between it and drum *c*, then over the latter, encircling one half its periphery, and nearly describing a figure ∞; it then dives, goes under the drum below *c*, under *e*, recurves upwardly over *c*, then again over *g*, following another groove to its former course, the pulley *e* being set obliquely so as to give the rope the lateral deviation. To resume: the rope, passing back over *g*, goes over pulleys *b* and *c*, repeating its figure ∞ course, coming out under *c* and going around *f*, and thence to the ear on the upper of the two tracks, as shown in the plan *B*. The pulley *F* is set obliquely so as to change the rope over to the other track. *n* is the level railway at the head of the slope *m*.

The parts have been disjointed for convenience of disposition on the page; the part *A'* belongs at the right hand of *A*, a long intervening stretch of 2,400 feet of wire being understood. The same may be said of the proper position of *B'* at the right of the portion *B*, which is a plan of the machinery at the head of the incline. The steam cylinders are 32 inches in diameter, and 7 feet stroke. The drums make 32 revolutions in a minute, the velocity of the rope being 1,400 feet per minute.

Some magnificent engineering works are to be found among the mountain regions of the world, where the grades are ascended by inclined planes. Among these may be cited some on the Callao, Lima,

Fig. 2664.



Plan of Inclined Planes on the Callao, Lima, and Oroya Railway, Peru.

and Oroya Railway in Peru. The annexed engraving shows portions at Sureo, the Parac, and San Bartolome, respectively. They are not "air lines" by any means. The grades are from 2½ to 4 per cent (211 feet to the mile); curves are limited to 400 feet radius.

Mr. Meiggs is doing a great work. The western slope of the Andes at this point has no timber, nor

for fifty miles on the east side. Oroya is thirty miles east of the summit tunnel, which is 15,200 feet above the level of the sea. At this hight you cannot cook beans in an open vessel, as the boiling-point is not hot enough. The railroad buildings and bridges are of iron, and come from England, as do the rails; the ties are from Oregon, the locomotives and cars from the United States.

The plate opposite is a view of the Furka pass and the Rhone glacier, Canton Valais, Switzerland. The winding road is shown in the view, climbing up a spur of the mountain, which is immediately west of Mt. St. Gothard. See also views in "Lippincott's Magazine," Vol. VIII. p. 324; and London "Engineer," Vol. XXXII., 1871, p. 233.

The longest inclined plane on an artificial road is said to be that from Lima to Callao, which is about 6 miles, and has a descent of 511 feet, or about 1 in 60.

The ascent from the Konkan, or flat country of Bombay, by the Western Ghauts to the table-land of the Deccan, is known as the Bhore Ghaut incline, in which the railway rises from the plain 2,000 feet in a series of steps 16 miles in length.

The Righi Railway in Switzerland rises by a locomotive of peculiar form 1,170 feet in traversing 4,700. The boiler, furnace, and carriage are inclined so as to present a level floor on the slope.

The inclined plane or railway of Mt. Washington is familiar to many tourists.

In this connection the following data may be useful: —

The pressure on a level pike against the collar is, say, $\frac{1}{35}$ of the load. An ascent of 1 in 35 would double the draft, and may be a suitable maximum ascent. The French maximum is 1 in 20. Telford's maximum was 1 in 30. Simplon, Italian side, average 1 in 22; Swiss, 1 in 17.

Angles. Degrees.	Inclination.	Feet per Mile.	Angles. Degrees.	Inclination.	Feet per Mile.
¼	1 in 115	46	0° 23′	1 in 125	42
¾	1 in 76	69	0° 35′	1 in 100	53
1	1 in 57	92	1° 9′	1 in 50	106
1½	1 in 38	138	1° 16′	1 in 45	117
2	1 in 29	184	1° 26′	1 in 40	132
2½	1 in 23	231	1° 38′	1 in 35	151
3	1 in 19	277	1° 55′	1 in 30	176
4	1 in 14	369	2° 18′	1 in 25	211
5	1 in 11	462	2° 52′	1 in 20	264
			3° 49′	1 in 15	352
			4° 24′	1 in 13	406
			5° 43′	1 in 10	528

Inclined planes were used for raising the galleys and triremes of the Greeks from the waters of the Corinthian or the Cenchreæn Sea, for transportation across the Isthmus of Corinth. This was the *Diolcos* or drawing-place, 40 stadia or 5 miles in length, the narrowest passage between the two gulfs. A canal was attempted at this point by Julius Cæsar, Caligula, Nero; the ridge of native rock defeated all the attempts; it is very hard, and can hardly be worked without blasting. The incline was again used in the wars of the Genoese and Turks.

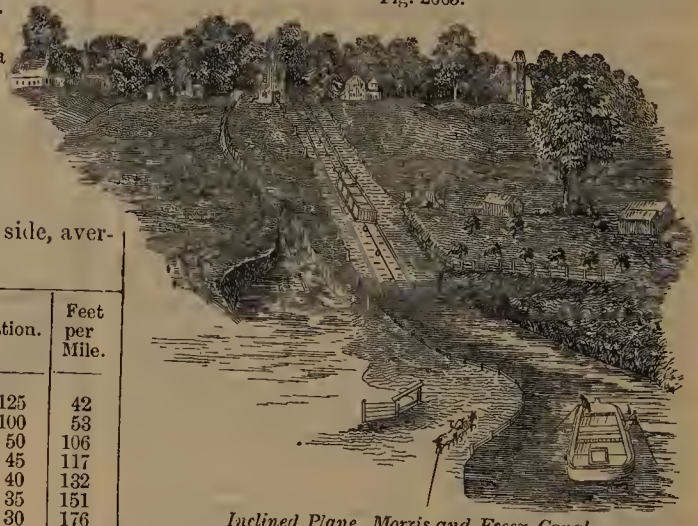
Inclined planes and *lifts* for raising and lowering canal-boats from one level to another, as a substitute for locks, are mentioned by Smeaton in 1774. Both systems are used on the English canals, in the neighborhood of Taunton; 80 feet of rise are overcome in this way.

The *inclined plane* has a steam-engine on the summit, which, by means of a drum and chain, hauls up the cradle containing the boat.

The *lifts* are worked by one attendant, who can raise or lower a boat from one level to another. There are two lock-chambers, over which is a lofty frame, having large wheels and chains, by which are suspended the cradles, into which the boats are floated when they are to be raised or lowered. See LIFT.

On the Morris and Essex Canal, which crosses the State of New Jersey, connecting the Hudson and Delaware Rivers, there are, or were, 13 inclined planes, up which the canal-boats are hauled, the grades being thus ascended and descended without locking. The summit level at Stanhope is 900 feet above tide-water, and the changes of grade are sudden and frequent. A track of heavy rails is laid on the inclined plane, which has a grade of about 15°, and on this the cradle containing the boat ascends at the rate of five or six miles an hour. At the summit is the motor, consisting of a water-wheel, driven by the water on the upper level. The wheel is connected to a shaft carrying a drum, on which is wound a wire rope about two inches in diameter, and connected at either end to the cradle which contains the boat, and which forms a car for its conveyance. This car is a heavy frame running on flanged wheels, and descends a sufficient distance into the water to

Fig. 2665.



Inclined Plane, Morris and Essex Canal.

enable a boat to float into it, where, being secured, the car and boat ascend or descend the inclined plane together. From the forward end of the car the wire rope passes over anti-friction rollers between the rails of the track to and around a large submerged wheel some 100 feet distant from the summit, thence over the drum and other friction-rollers by the side of the track to another submerged wheel at the foot of the plane, around which it passes, and is attached to the rear end of the car. The boat is made in sections, to enable it to accommodate itself to the inequalities of the track when passing over the summit.

Arriving at a plane, the boat is drawn into the car in the order of its arrival, the team is unhitched, the tow-rope coiled on deck, the boat secured to the car by hawsers, and its two sections disconnected by a lever which pulls out the bolt uniting the hinge. The blade of the rudder is then raised out of harm's way, and the signal is given for the engine to start. After passing the summit the brakes are put on, and the car descends into the water where the boat floats out of it, and the tow-rope is again attached. In one place the canal has a fall of 200 feet, 80 of which are overcome by a single plane of 800 feet length, and the remainder by means of locks.

INCLINED PLANE.

PLATE XXVII.

THE RHONE GLACIER, FURKA PASS.

See page 1176.

A mode by which canal-boats are enabled to ascend inclined planes while preserving their usual horizontal position was invented in England, but it is not known to the writer whether it was ever successfully put in practice. The carriage which received the boat had a forward pair of wheels which ran upon one double track, while the rear end (to the ascending boat) was supported by other wheels, which ran on another track set at such a distance outside of and higher than the former as to give the required level position to the carriage. The inclined boat-carriage is also shown in Day's United States patents for inclined planes and cradles for canal-boats.

In-cli-nom'e-ter. 1. An instrument to detect the inclination or dip, the vertical element of the magnetic force. Many delicate instruments have been constructed for this purpose, but the best known is the DIPPING-NEEDLE (which see).

2. An instrument to measure the slope of an embankment, slope, or incline. It may have an alidade with a level; an arc, and a base-piece which lies on the slope. A *batter-level.*

In-crease'-twist. (*Rifling.*) A rifle-groove which has an increased angle of twist as it approaches the muzzle, allowing the projectile to be easily started and giving it an increased velocity of rotation as it proceeds.

Rifling was known in the seventeenth century; its inventor and date being unknown. Mere grooved barrels, without spirality, were used two centuries earlier.

The increase twist is credited to Tamisier, and dates but a few years back.

In-crus-ta'tion. 1. (*Masonry.*) A facing or covering to a wall of a different material from that of which it is mainly built, such as marble or stone.

2. A thin sheet of wood applied upon a wooden surface. See VENEERING.

3. (*Steam-engine.*) The deposit from the water adhering to the inside of a boiler.

As nothing but pure water enters into the composition of steam, it has long been a problem in steam-engineering to get rid of impurities in water which it is found necessary to use in steam-boilers. Among these impurities may be mentioned the salt in sea-water, lime in the water of limestone regions, and minerals in many forms, which are often found in water supposed to be pure until thus tested.

The accumulation of salt in a marine boiler would soon fill it, if there were no way for its removal. In practice it is generally "blown off," when the *salinometer* indicates a certain point of saturation.

Lime in some forms incrusts a boiler very rapidly, having been known to form a *scale* several inches in thickness in a few days. This scale is a poor conductor of heat, and a large proportion of the products of combustion are lost by its interposition. It also weakens the boiler, and has been the cause of many explosions.

Condensers are used to supply pure water to boilers. See CONDENSER.

Feed-water heaters have a purpose, besides utilizing waste heat, to compel the deposition of impurities before the feed-water reaches the boiler.

Mechanical agitators, beaters, scrapers, etc., are often employed to remove crust from a boiler.

Chemical treatment of feed-water, or of water in the boiler, is a matter which has received much attention from engineers and scientists. Sawdust acts both chemically and mechanically to prevent incrustation, the tannic acid it contains uniting with the lime to form tannate of lime, which deposits itself as a slimy body. Clay has sometimes given good results, but sand is almost always present in some quantity, though small, and, if it passes over in priming, is very detrimental to the valve-faces, the cylinder, and the piston. Starch and sugary substances have the effect to clarify some waters, the viscid character of the glucose preventing agglomeration of the foreign matters, and forming scum instead of crust. Fatty bodies, tar, and graphite tend to prevent adhesion. The nature of the water to be treated determines the substance which shall be used.

Scott's English patent, 1828, describes a mode of catching the deposit which forms the incrustation by placing pans or trays in the boiler; these intercept the falling deposit.

Taylor's English patent, 1830, has a sediment-trough the length of the boiler, and forming a narrow chamber below the same, out of contact with the fire. The contents of this chamber are occasionally blown out, carrying the sediment.

To avoid the expenditure of space in stating at length the various materials which have been placed in steam-boilers to retain the mineral particles in suspension, or to prevent their adherence to the boiler, it may be stated that they consist of —

Acids, —
  Acetic.
  Hydrochloric.
  Muriatic.
  Nitric.
  Oxalic.
Alkalies.
Ammoniacal salts.
Animal fats, —
  Marrow, etc.
Arsenical salts.
Ashes.
Barks in great variety Ground
Baryta.
Black-lead.
Bones, Ground
Borax.
Bran.
Broom corn.
Burgundy-pitch.
Camphor.
Carbonates in variety.
Caustic alkalies.
Charcoal.
Chlorides in variety.
Clay.
Coal-tar.
Copper. Salts of
Copper scraps.
Cream of tartar.
Creosote.
Cutch.
Decoctions of bark.
Dextrine.
Electric devices.
Fatty oils.
Felt.
Fibrous materials.
Flaxseed.
Galvanizing devices
Gambier.
Gas tar.
Glass. Broken
Glue.
Graphite.
Gravel.
Gums in variety.
Hay
Horns. Internal portions of
Hydrocarbons.
Iron. Salts of
Iron scraps.
Isinglass.
Kerosene.
Lampblack.
Lead. Salts of
Leather scraps.
Leaves in variety.
Lime.
Lime-paint.
Linseed-cake.
Linseed-oil.
Logwood.
Malt.
Meal.
Metal in strips or scraps.
Molasses.
Moss.
Mucilage.
Muriates in variety.
Nutgalls.
Oak-bark and sawdust.
Ochre.
Oils in variety.
Oxalates in variety.
Oxides in variety.
Paints in variety.
Peat.
Petroleum.
Phosphates in variety.
Pitch.
Plants of various kinds.
Plumbago.
Potash.
Potatoes.
Resins.
Sal-ammoniac.
Sand.
Saponaria.
Sawdust of various woods.
Shells. Ground
Soap.
Soda.
Soda-ash.
Soot.
Sponge.
Starch.
Stones.
Sugar.
Sulphates in variety.
Sulphur.
Sumac.
Tallow.
Tan-bark.
Tannin.
Tar.
Terra-japonica.
Tin. Salts of
Tobacco.
Turf.
Turmeric.
Urine.
Valonia.
Vegetable dyes.
Voltaic devices.
White-lead.
Wood-fiber.

In'cu-ba-tor. A device for hatching eggs by artificial means.

The hatching of poultry by artificial heat is not mentioned by Herodotus, but is described by Diodorus Siculus as an ancient practice. The ancients

obtained the heat by the fermentation of manure; the modern Egyptians by the regulated heat of ovens.

The ordinary domestic fowl is a native of India, and is neither mentioned in the Old Testament nor depicted on the paintings of Egypt. It was known in Palestine at the Christian era, and is supposed to have been introduced by the Romans into the countries they subjugated; perhaps earlier by the Persians, but this does not clearly appear. They were common in Greece.

The references to eggs in the Old Testament refer to those of wild birds, such as ostriches and partridges. That in Luke no doubt was the ordinary hen's egg. The word, in the singular or plural, occurs but twice in the Old Testament, five times in the New.

The business of egg-hatching is conducted by the Copts, who carry it on in Upper and Lower Egypt and pay a license to the government. A building containing from 12 to 24 ovens is called a *maamal*, and its charge is 150,000 eggs. An official report for 1831 gives for Lower Egypt 105 of these establishments, using 19,000,000 eggs, of which 13,000,000 produce chickens. This saves the valuable time of 1,500,000 hens for three weeks of inactivity and several succeeding weeks of care and scratching, enabling them to devote their undivided attention to the other duties of maternity, egg-laying and cackling.

The proprietors of an oven collect the eggs from the peasants in the vicinity. The eggs are placed on mats strewed with bran, and are changed to positions nearer to or farther from the heat of the fire-chamber till the expiration of six days, when they are tested by a strong sunlight for signs of the formation of the chicken; four more days in the warmest position, five days in a closed chamber, and they are then spread separately over the surface of the mats, being frequently turned and changed from one part of the mats to another during 6 or 7 days, outside air being carefully excluded. They are frequently tested for signs of life, the test being greater coldness than the eyelid of the attendant. The chickens appear within 21 days, but some with thin shells hatch earlier. The usual number that succeed is two thirds, of which half belong to the peasants and half to the proprietors of the oven.

The size of the building depends on the means of the proprietors; but the general plan is usually the same, being a series of eight or ten ovens and upper rooms, on either side of a passage about 100 feet by 15, and 12 in hight. The thermometer in any part is not less than 24° Reaumer (86° Fah.); but the average heat in the ovens does not reach the temperature of fowls, which is 32° Reaumer. Excessive heat or cold are equally prejudicial to this process, and the only season of the year at which they succeed is from the 15th of Innsheer (23d of February) to the 15th of Baramoodeh (24th of April), beyond which time they cannot reckon upon a sufficient percentage to make it a paying business.

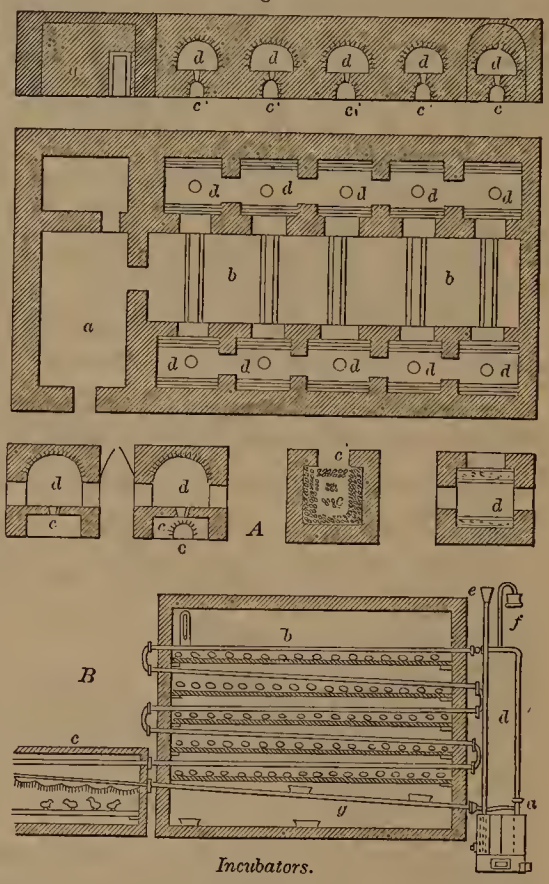
The illustration *A* (Fig. 2666) shows the modern Egyptian oven for hatching eggs.

a is the entrance room, and *b* the passage between the rows of ovens on each side. The chamber *c* for the eggs is below the one *d* in which the fires are made in troughs alongside the walls, the heated air passing to the chamber below by a hole in the floor dividing the two apartments. The illustration gives several horizontal and vertical sections, the entrances to the egg-chambers showing in the upper view at *c*. The upper chambers are connected.

The ancient Egyptian incubators are referred to by Aristotle, Diodorus Siculus, and Flavius Vopiscus.

Bonnemain's incubator *B* (A. D. 1777) is heated by hot water. *a* is the boiler; *b*, a building for holding the eggs on shelves; *c*, a coop for holding the chickens; *d*, tube for circulating the hot water; *e*, a supply funnel; *f*, a safety tube. The hot water

Fig. 2666



Incubators.

rises from the boiler into tube *d*, thence follows the sinuous course of the tube above and below each shelf, and into the chicken-coop, eventually discharging into the boiler again by the pipe *g*.

There is some difference in temperature in the interior of the box as the convoluted pipe parts with its heat sufficiently to establish a circulation in the pipe.

The force of the circulation is in the ratio of the difference between the temperature of the water, passing out of the calorifère and re-entering it; any unusual degree of coldness in the lower part of the box will thus react, and increase the speed of the circulation, the normal tendency of the scheme being towards equalization.

The point to be regulated is the heat of the furnace, and this is accomplished by a thermostat, founded upon the unequal dilatation by heat of different metals. A compound metallic bar exposed to the heat of the chamber warps when the heat exceeds the medium, and draws upon a wire connected to the door of the ash-pit, and thus regulates the draft.

Pans of water secured the proper humidity of the air.

Periods of incubation; temperature, 140° Fah.

Swan	42 days.	Peafowl	28 days.
Goose	35 "	Duck	28 "
Hen	21 "	Pigeon	14 "
Turkey	28 "	Canary	14 "

In-dent'. 1. (*Carpentry.*) A notch, as in scarfing timbers together.

2. (*Printing.*) The blank space or *set-in* at the commencement of a paragraph.

In-den-ta'tion. (*Architecture.*) A zigzag molding. The shark's tooth molding. *Denticulation.*

In-dent'ed Chis'el. A boring-chisel whose face is in steps.

In-dent'ed Line. (*Fortification.*) One consisting of alternate salient and receding angles, each face forming a flank to its neighbor.

In-dent'ed Par'a-pet. (*Fortification.*) One whose interior slope has vertical recesses in which men may stand and fire along the front of the work.

In'de-pen'dent Piece. (*Shipbuilding.*) The main piece of the *head* or beak-shaped projection from the stem of a vessel. See STEM.

In'de-pen'dent Sec'onds-watch. A watch in which the action of the center seconds-hand is independent of the regular going works of the watch. It has two separate trains of wheels and separate springs, so that the regular time may be maintained when the center seconds-hand is stopped by pressing the stop-pin on the outside of the case.

The center seconds is set in conformity with the other works by a *square* at the back of the case.

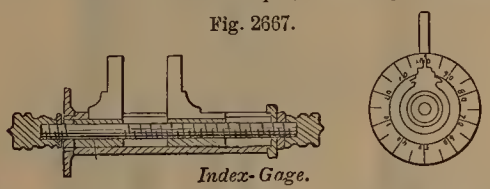
For great nicety in timing, quarter and fifth second watches are now made, and are capable of being stopped at the said fractional parts of a second.

In'dex. 1. A pointer, as the hand of a watch or clock, a finger or arm of a balance or measuring apparatus which moves along a graduated scale, or in relation to a line or central mark.

2. A brass rule accompanying the plane-table, furnished with perpendicular sight-vanes at each extremity. An *alidade.*

In'dex-gage. An instrument having jaws whose distance apart is indicated by a pointer and dial, or other means. In the example, the body to be meas-

Fig. 2667.



Index-Gage.

ured is placed between the jaws, which are brought in contact with the opposite sides. The thirty-seconds of an inch are indicated by the jaw on the scale on the cylinder, and the hundredths of a thirty-second are indicated by the hand on the dial.

In'dex-glass. A mirror at the center of motion of the index-arm of a quadrant or sextant, which moves with the index, and from which a ray of light from one of two given objects (one of which is, say, the sun) is reflected to another mirror, called the *horizon-glass*, fixed to one of the arms, and thence to a sight-hole in the other arm. See QUADRANT; SEXTANT.

In'dia-ink. A composition of lampblack and size. Said to have been formerly made from the pigment of the cuttle-fish. The ink of the Chinese scribe, used with a brush.

In'di-an Steel. A fine kind of steel, made in Southern Asia direct from the ore, and known as *wootz.* The *natural* steel of India.

In'dia-pa'per. The name given to a paper made with one exceedingly fine surface, and used for taking the finest impressions of steel, steel-plate, and wood engravings. It is made by the Chinese from the inner bark of the bamboo. It is imported in sheets 25 × 26 inches. The Chinese also make paper of the barks of the elm and mulberry, of the cotton-tree, hemp, wheat-straw, rice, and rice-straw. See WOOD-PAPER.

In'dia-rub'ber. India-rubber in the crude state is prepared for manufacture by grinding the sheets in water, for the purpose of cleansing it. After this it is dried and subjected to the tearing action of toothed rollers, one of which revolves faster than the other. At this stage the vulcanizing material, consisting of ½ ounce of sulphur or more to the pound of rubber, according to the required hardness, is added and thoroughly incorporated. Various other ingredients, as sulphate of zinc, whiting, plaster of paris, lampblack, pitch, etc., in addition to the sulphur, are also employed for the purpose of hardening. The selection of these depends on the peculiar ideas of the manufacturer and the destined application of the material.

In making boots and shoes the rubber is passed, in contact with cotton cloth, between heated rolls which rotate at different speeds, and is forced between the interstices of the cloth, to which it becomes firmly united. In some cases the rubber is drawn, either with or without the cloth, through rolls of equal speed, to a thickness suitable for the soles or uppers of shoes. The sheets thus formed are cut up, by suitable dies, into the proper forms for the soles and uppers, which are afterward cemented on a last by a solution of rubber dissolved in benzine. At this stage a coating of linseed-oil varnish is applied with a brush, and the shoe subjected to a heat of about 280° Fah., when the operation is complete.

In making hose or tubing, the rubber or rubber cloth is wrapped around a tube until the desired thickness is attained, and placed in a steam-heater at a temperature of about 280° Fah., which partially fuses the compound, causing the layers to unite. It is then removed from the heater and the tube withdrawn.

Belting is formed by laying together a sufficient number of layers of the vulcanized gum or gum-cloth and subjecting them to the action of a flat press at a heat of 280° Fah. Additional hardness is attained by the use of a larger proportion of sulphur and the application of greater heat.

The operation of uniting several layers of the material is, however, performed with much more expedition by the use of a steam cylinder-press.

Previous to 1821, it is said that india-rubber had only been brought to this country as an article of curiosity, molded into various fancy forms, as alligators and other reptiles. In that year a pair of what appeared to be solid models of shoes were brought home by a sea-captain, who presented them to an ingenious boy. Curiosity led him to cut into them at the instep, when he found a clay mold inside, this he removed, and finally, by dint of heating and stretching, adapted them for wear. This becoming known, led to the importation of the native shoes made upon clay lasts. See CAOUTCHOUC.

No process has yet been devised for restoring old rubber to the condition in which it was previous to vulcanization. It is, however, extensively used for mixing with new raw material in the manufacture of all kinds of rubber goods. By steaming and rolling it is reduced to a semi-plastic state, and in this condition it is applied to coarse fabrics and used for heel stiffening, a purpose for which it is well adapted. Pure rubber is but little used except for artists' purposes.

In'dia-rub'ber, Ar-ti-fi'cial. A compound of chloride of sulphur, oil, and collodion. In its plastic state, it is easily molded, and hard and durable when well set. It can be made of any color, and is susceptible of a high polish. An English compound consists of linseed-oil oxydized on glass plates by repeatedly dipping the plates in the oil, and allowing it to dry each time. The film thus obtained is removed from the glass, crushed, and worked by the

mixing rolls, a small quantity of gum-shellac being added to give it the proper cohesion. The substance thus obtained is very much like rubber, and can also be vulcanized.

In'dia-rub'ber Bind'ing. A mode of binding books patented in England by Hancock, in which the usual operations of stitching, sawing, and hammering the back are dispensed with. The sheets are placed in a former to give the proper curvature to the back, and are then secured by packthread. They are next placed in a press, with their backs slightly projecting, and several coats of a solution of india-rubber applied, after which the bands are attached by means of the india-rubber solution, and the cover put on in the usual way.

In'dia-rub'ber Cloth. (*Fabric.*) Fabric covered with india-rubber. The latter is cleaned, triturated with sulphur, dissolved in benzine, or other solvent, and spread upon fabric by rolls.

In'dia-rub'ber Rolls. Rolls whereby rubber-cement, mixed with sulphur, and dissolved in benzine or other solvent, is spread upon fabric.

Some of these rolls spread the cement by a frictional action, the heated spreading-roll traveling faster than the cloth-carrying roll, and so grinding the gum into the cloth.

Gum mixed with paint is spread in a layer of the required thickness upon fabric, by rolls of even motion; and the rubber fabric is then cut into pieces according to pattern, for boot or shoe soles, etc.

In'dia-rub'ber Spring. The first known use of india-rubber for springs is in Lacy's English patent of 1825. He employed blocks of rubber with interposed plates of iron. Melville, 1844, obtained a patent for hollow spheres of rubber, enclosing air and separated by disks of wood or metal, the whole enclosed in iron cases. In 1845, Walker and Mills patented rubber bags filled with air and enclosed in a case for use as springs. Fuller, 1845, cylindrical rings of rubber having perforated disks between them, and a guide-rod passing through the whole. These had a tendency to swell out at the center under pressure, breaking or injuring the material. To remedy this defect, Spencer, 1852, 1853, formed the rubber rings of the shape which they would assume under pressure, and surrounded them with an annulus of iron. These have been used as buffer, bearing, and draw springs for railway-carriages with satisfactory results. (See also CAR-SPRING.) Eaton, 1856, employs alternate thin plates of rubber and metal, adapted for springs of great resistance and little flexibility. Hodge, 1852, patented a compound spring composed of a block of rubber inclosed in a two-part casing, the upper part surrounding the lower, and rising or falling according to the amount of compression of the rubber placed on each end of a steel spring. Scott, 1852, blocks of rubber placed over the center of a steel spring. Bridges, 1857, employs wooden instead of iron surrounding rings to confine the rubber blocks, and dispenses with the central rod. Fuller, above referred to, employs for suspension springs round cords, wound at a considerable tension around two metallic rollers or reels. During the Russian war, a number of mortar-boats were built by the British government, each carrying a 13-inch mortar. In order to diminish the shock occasioned by the recoil of such heavy ordnance on these small vessels, twenty very strong rubber rings were placed under each mortar-platform. These were tested by actual service at Sveaborg, in the Black Sea, and afterward in China, with very satisfactory results.

In'dia-rub'ber Thread. This is prepared by cutting a sheet into filaments, which are then stretched in a hot atmosphere or hot water; the process being several times repeated with alternate coolings. It is glazed by agitating with French chalk-powder.

In'di-ca'tor. A marking or recording instrument, or one which makes a visible sign by which the condition of the object or apparatus to which it is attached may be observed. The various uses to which indicators are applied may be suggested by the following: —

Door-indicator.	Station-indicator.
Leak-indicator.	Steam-indicator.
Leeway-indicator.	Street-indicator.
Shoal-indicator.	Tourists'-indicator.
Speed-indicator.	Weather-indicator.

Besides these compound forms, the term has also many other applications; as, —

The gradient post of a railway.

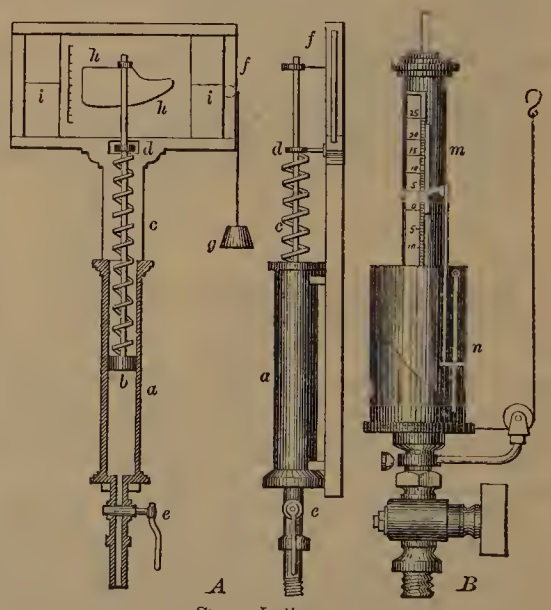
A gage in a blast furnace to indicate the proper hight of a charge.

The principal meaning of the word, however, concerns the instrument by which working steam records its pressure.

1. (*Steam-engine.*) An instrument which registers the relative amounts of steam pressure exerted on the piston at each portion of its stroke. It was invented by Watt.

Watt's indicator *A* consists of a cylinder *a* in which works a piston *b*, that is (when the cylinder

Fig. 2668.



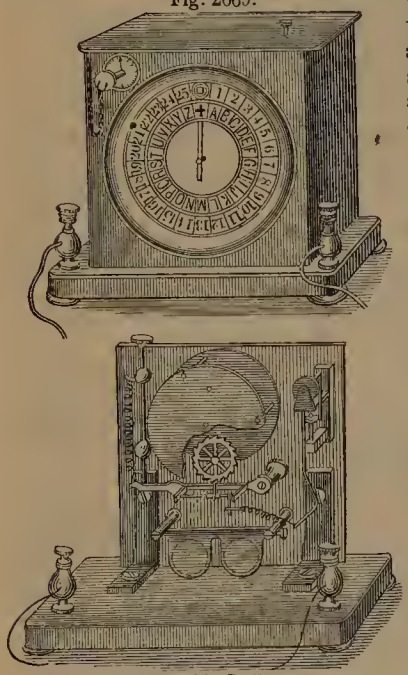
Steam-Indicator.

is not in communication with the steam-cylinder) maintained near the midlength of the indicator cylinder by the spiral spring *c*. The piston-rod works through a collar *d*, and has at its upper end a device for holding a pencil. Communication with the steam-cylinder is effected by the cock *e*, and when steam is admitted through this it causes the piston to rise, compressing the spring with a force equal to the excess of the steam pressure above that of the atmosphere. When a vacuum is produced by the condensation of the steam in the cylinder, a corresponding vacuum is formed in the indicator, causing the piston of the indicator to be forced down by a pressure equal to the excess of the atmospheric pressure over that of the uncondensed vapor in the cylinder. In order to register this, a small square movable frame *f* is placed at the upper end of the indicator, in which a card is inserted. One end of the frame is attached

by a cord to some movable part of the engine, and the other has attached a string and weight. When the piston rises, the card is drawn to the left, raising the weight *g*, which, when the piston descends, draws back the card to its first position. An alternate reciprocating motion of the card is thus kept up. Thus as the piston of the indicator rises and falls, its pencil traces on the card a line whose vertical ordinates represent the actual pressure, and whose length corresponds to the length of stroke of the piston. The *diagram* thus formed is shown at *h h*. All above the median line *i i* indicates the pressures on the piston, and all below it the vacuum, or the difference between the pressure of the uncondensed vapor and that of the atmosphere.

B (Fig. 2668) shows a modification of the above, which is provided with an upright graduated cylinder *m* surrounded by a larger cylinder *n*, upon which the registering paper is placed. This has a partial rotation back and forth by means of a cord connected to some part of the engine which has a reciprocating motion and a spring which restores it to its first position.

Fig. 2669.



Telegraphic Indicator.

2. (*Telegraphy.*) The dial and mechanism of a dial telegraph. Fig. 2669 shows Breguet's.

The face has the letters and figures arranged in two concentric circles. The motion of the hand is continuous in one direction, advancing one letter at each closing of the circuit. This movement is effected by clock-work driving a scape-wheel, the teeth of which are alternately engaged and released upon opening and closing the circuit, by means of a pawl operated intermediately from the armature of the electro-magnets.

3. (*Optics.*) A finger working in the field of a microscope to point out a special object within the field of view.

4. A dynamometer or power measurer.

In'di-ca'tor-card. A card containing a diagram drawn by the working steam by means of an INDICATOR (which see).

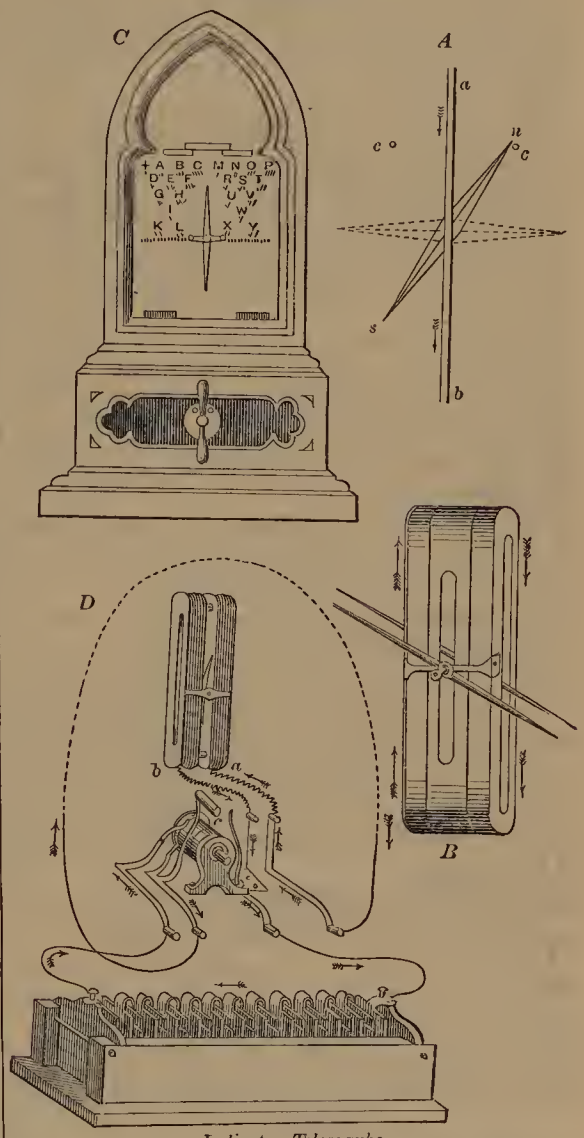
In'di-ca'tor-tel'e-graph. An electric telegraph in which the signals are given by the deflections of a magnetic needle.

It was about 1819 that Œrsted of Denmark made the discovery that if a magnetic needle, free to turn about its center, were placed near to and parallel with a wire, then, on causing an electric current to pass through this wire, the needle would be deflected to an angle proportioned to the force of the current.

In Fig. 2670, *A*, *a b* being the wire and *n s* the needle, the passage of a current in the direction of the arrow deflects the needle to the position indicated, the stops *c c* limiting its motions. When the direction of the current is changed, the *n* (north) pole of the needle is deflected in the other direction. By a preconcerted system, a given number of movements to right, left, or a certain number in alternate directions, a system of indications representing letters and numerals is obtained, as will be explained presently.

In practice, a pair of needles, rendered astatic (see ASTATIC NEEDLE), are used and placed in conjunction with a coil of wire, which multiplies the transmitted current so as to cause a much greater deflection than that due to the line current itself, as shown at *B*, which consists of a frame around which are wound several hundred feet of fine copper wire. The needles are mounted on the same axis, one within and one without the coil, and the outer one is exterior to the dial-plate of the telegraph.

Fig. 2670.



Indicator-Telegraphs.

Following the discovery of Œrsted, Ampère in 1820 suggested that the needle moved by the galvanic current should be used for conveying signals, and the idea was elaborated in lectures by Ritchie in 1830.

Baron Schilling, in Russia, in 1832, contrived a complicated instrument on this principle, in which a separate circuit and needle was employed for each

letter and numeral, 36 needles being employed, each being excited by a current of electricity as the occasion required.

Cooke and Wheatstone's indicator-telegraph, patented June 12, 1837, is the most prominent and best example of this class of instruments, and is generally used in England.

America and the continent of Europe employ the much superior system of Professor Morse, introduced about the same time.

C is a front and *D* a rear view of Wheatstone's instrument. In this the right and left hand terminals *a b* of the multiplier are each connected to the line-wire, which is, when a message is not being transmitted, thrown out of connection with the local battery.

The circuit is opened and closed by means of a drum *c*, at each end of which is a stout steel wire forming respectively the positive and negative poles of the battery; these wires, on turning the drum, are brought in contact with springs connected with the line-wire, by which either a positive or negative current is transmitted, causing the needle at the receiving station to be deflected to the right or left accordingly.

The letters of the alphabet and other signals are indicated by the number of beats made by the needle, some to the right and others to the left; thus "D" is represented by a beat to the right and one to the left. "L" requires four beats, in the following order, right, left, right, left, and so on for other letters.

The double-needle telegraph on the same principle is much more expeditious, and has been extensively employed in England, but requires two line-wires. See ELECTRO-MAGNETIC TELEGRAPH.

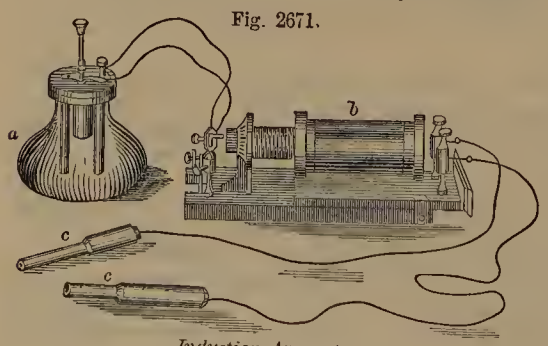
In-di-gom'e-ter. An instrument for ascertaining the strength of indigo.

In'di-go-mill. A four-sided iron cistern, cylindrical or rounded at bottom, resting upon gudgeons in a wooden frame. It has an iron lid with two leaves, between which works a rock-shaft receiving a vibratory motion from a crank, and imparting a swinging motion to a frame carrying six rollers, three on each side, which triturate the indigo to a fine paste; when sufficiently ground, the paste is drawn off by a stop-cock.

In-duc'tion. (*Electricity.*) That effect of an insulated electrified body which tends to produce an opposite electrical state in surrounding bodies.

In-duc'tion-coil. A compound coil by which voltaic or dynamic electricity is converted into static electricity or electricity of high tension. The discoveries of Faraday, Henry, Bequerel, and others led the way to the invention of the induction-coil, and it is believed that the first practically useful device

Fig. 2671.



Induction-Apparatus.

of the kind was contrived by the late Dr. Charles G. Page of Washington.

Ruhmkorff, of Paris, having made many instruments of the kind and contrived various improvements, the instrument is now very generally called by his name.

It consists essentially of an inner coil of coarse wire surrounding a core of soft iron rods, and connected with the poles of a voltaic battery. It is itself surrounded by, though insulated from, a coil of copper wire composed of a great number of convolutions, and connected with the discharging conductor. By opening and closing the circuit with great rapidity, which is effected by means of the AUTOMATIC CIRCUIT-BREAKER (which see), a nearly continuous current is produced. To intensify this, the return current from the primary coil produced by the disruption of the current is passed through a CONDENSER (which see); the effect may be increased by breaking the current under crude petroleum or other non-conducting medium.

The induction-coil is practically applied to many purposes in the arts, and in the treatment of diseases by electricity. Fig. 2671 is an instrument of this kind. The battery *a* consists of a single Grenetts cell, supplied with dilute sulphuric acid and bichromate of potash. One zinc and two carbon plates compose the elements, the former of which is lifted clear of the fluid when not in use. A vibrating spring opens and closes the circuit. *b* is the coil, and *c c* two dischargers, by means of which the current is directed to any part of the person.

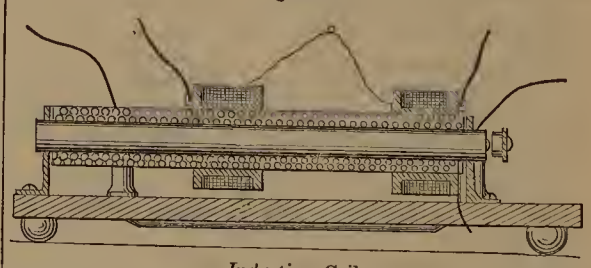
In the largest class of induction instruments, electricity of very high tension is produced.

One belonging to the Stevens Institute of Technology weighs 160 pounds; the primary wire is 200 feet and the secondary about 44½ miles in length. This projects a spark 21 inches in length and capable of penetrating glass three inches thick.

Another, at the Polytechnic Institute of London, has its primary wire 3,777 yards long, and weighing 145 pounds. The induction-wire is 150 miles long. This projects a spark 29 inches long, penetrating 5 inches of plate-glass. Its calorific effects are very intense, the most refractory substances, as platinum, being fused with ease.

In Kidder's induction-coil, the secondary helix or helixes are adjustable, so that they may be either concentrated at the central or neutral portion of the

Fig. 2672.



Induction-Coil.

primary coil or placed toward the poles, so as to vary the power of the induced currents. See Noad's "Inductorium."

Electrical machines of great power are now constructed on the induction principle.

In-duc'tion-pipe. (*Steam-engine.*) The pipe which leads the live steam to the cylinder.

In-duc'tion-valve. The valve which controls the entry-port for live steam to the cylinder of an engine.

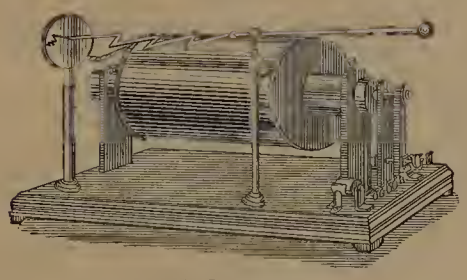
In-duc-tom'e-ter. An instrument for ascertaining the force of electrical induction.

In-duc-to'ri-um. (*Electricity.*) Another name for the induction-coil as adapted for the display of

the electric spark. The instrument shown was constructed for the Royal Polytechnic Institution of London, and gave a spark 18 inches in length.

In Ritchie's instrument, the *secondary* consists of coils wound up into flat disks the thickness of the wire, and these are piled up against each other upon the primary coil, the separate coils being separated by thin disks of gutta-percha. The current is made to reverse from the center to the circumference and

Fig. 2673.



App's Inductorium.

conversely, to and fro, as many times as there are coils upon the core.

In-fe'ri-or Let'ter. Letters cast with their faces low down on the shank ; as 4_b.

In-flect'ed Arch. 1. A reversed or inverted arch.

2. An arch, the curve of whose flanks is reversed near the crown, so as to terminate in an acute angle. (*c*, Fig. 305.)

In'gate. The aperture in a mold at which the metal enters. It then passes by *runners* to the spaces made vacant by the withdrawal of the pattern. The *ingate* is technically called the *tedge*, *gate*, *geat*, or *git*. The latter two are corruptions of *gate*.

In'got. A cast mass of steel from the crucible.

A cast mass of gold or silver, more or less pure, for *assaying*.

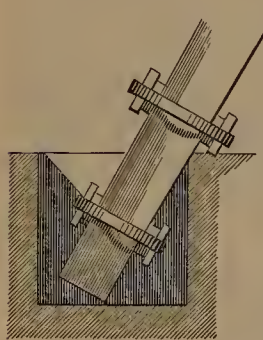
A cast block of gold, silver, or a properly proportioned alloy of either, for *coinage*, or for working into other forms, as watch-cases, etc.

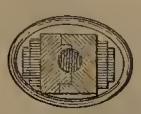
The crude ingot of gold or silver, after being assayed and brought to the standard fineness (varying according to its purpose), is cast into *bars* ready for rolling, if for coin.

Gold and silver are run into *ingots* or *bars*.

A transposition of *ingot* made *nigot*, which passed into *nugget*.

Fig. 2674.





Ingot-Mold.

Iron is cast into *pigs*.

Steel is cast into *ingots*.

Copper at one stage into *bricks*, at another into *pigs*.

Tin is run into *blocks*.

Silver from the subliming furnace is in porous blocks, called *bricks*.

The cast, flat lump of gold for the goldbeater weighs two ounces, and is $\frac{3}{4}$ of an inch broad.

In'got-mold. A flask in which metal is cast into blocks.

The *ingot-mold* for cast-steel is made of cast-iron, and of a shape and size to suit the form and volume of the steel bar or plate required. The mold is in two parts, separating longitudinally, and united for use by collar-clamps and wedges. The interior of the mold is smoked by the fumes of burning pitch, so as to give it a carbonaceous coating, the purpose of which is to prevent the adherence of the cast-steel thereto.

The operation of pouring the metal is called *teaming ;* the ingot is turned out while yet red-hot, and is rolled into the shape required.

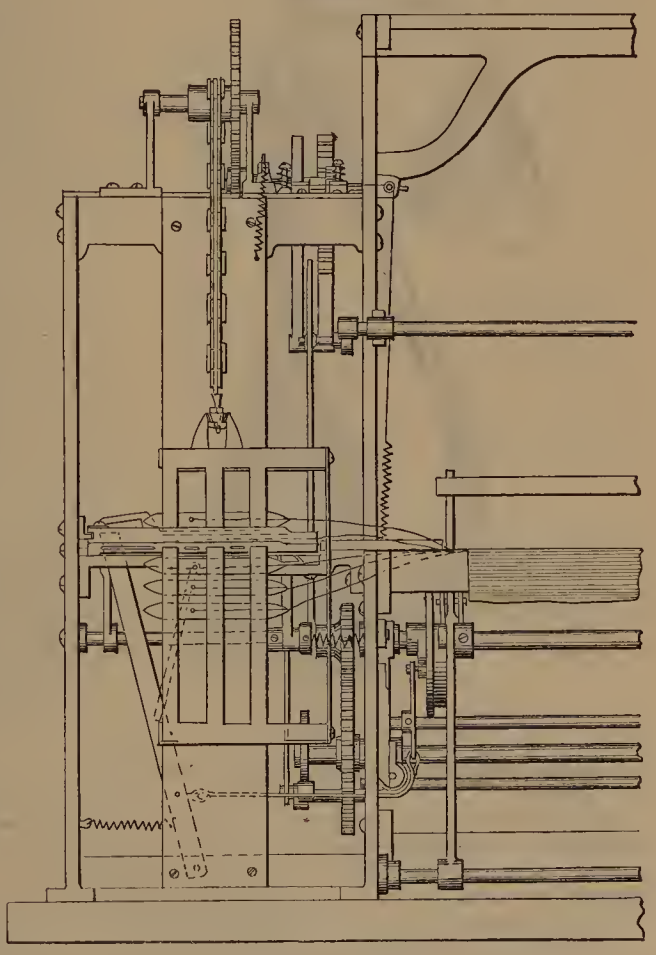
In'grain. A yarn or fabric dyed with fast colors before manufacture.

In'grain Car'pet. A carpet manufactured from wool or woolen dyed *in the grain* (before manufacture). These carpets are known as *Scotch* or *Kidderminster*, from the country and town where they are so extensively manufactured ; also as *two-ply* or *three-ply*, according to the number of webs of which the fabric is composed. See TWO-PLY CARPET.

In'grain-car'pet Loom. A loom in which two or more shuttles, one for the ground and the other for the figure, are employed.

In Bigelow's (Fig. 2675) the two, after being thrown, are received in horizontal boxes on each side of the frame, and a third series, containing the different colored yarns producing the pattern, are placed in a set of vertically arranged boxes ; all the shuttles are actuated by the same picker-staves ; and the figure shuttles are raised and lowered as required by pinions having a reciprocating rotary motion on a shaft, their presentation being determined by a pattern-wheel, having movable cam-surfaces on the

Fig. 2675.



Ingrain-Carpet Loom.

shaft; one vibrating cam moves the lay forward to beat up the cloth, and another moves it backward, while a shuttle is thrown.

In-hal'er. 1. An apparatus to filter and warm the air respired by persons with delicate lungs, or by those subjected to a deleterious atmosphere.

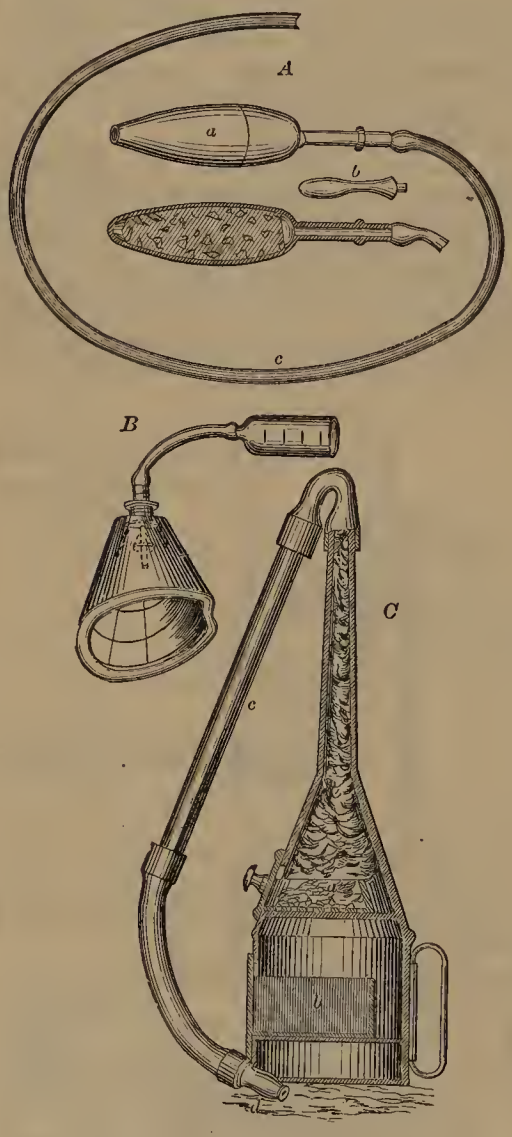
In apparatus for consumptives, it consists of a replicated wire-gauze tissue. A *respirator*.

2. For cutlers and others subjected to an atmosphere of iron dust, it is a magnetic tissue which arrests the dust.

3. An instrument for inhaling or inwardly applying medicated vapors or anæsthetic agents.

4. An apparatus to enable a fireman, miner, or diver to work in a poisonous or heated atmosphere,

Fig. 2676.



Inhalers.

or in water, carrying with him a supply of vital air. See DIVING.

Dr. Priestley's letter, speaking of "Gaseous oxyd of Septon" (*dephlogisticated nitrous air*), was addressed to one of the editors of the "New York Medical Repository," and was republished in the "London Monthly Magazine," June 1, 1800.

Chloroform was discovered by Guthrie, Soubeiran, or Liebig, about 1831, but its valuable properties as an anæsthetic were not appreciated until 1847. Dr. Morton of Boston, and Professor Simpson of Edinborough, discovered its applicability to this purpose almost simultaneously in 1847. See ANÆSTHETIC APPARATUS.

Morton's inhalation apparatus, November 13, 1847, has a chamber to hold the sponge, and two lateral openings through which respectively enter the atmospheric air and pass out the air impregnated with the vapor of the anæsthetic agent. These openings are valved to prevent reflux of air, and a chamber above contains a reserve of liquid, which is admitted to the sponge-chamber by moving a valve, at such times as may become necessary.

Roper's cup, October 10, 1848, is a vessel to hold sulphuric ether, and the rim fits closely over the mouth and nose. The body of the instrument then inclines downward, and an opening in front admits air, which passes into the ether-chamber, and then to the mouth and lungs of the patient.

Dr. Buttles's inhaler (*A*, Fig. 2676) consists of a bulb *a* of hard rubber in two sections, and containing a sponge which is charged with the required medicament. It has an opening at one end, which is closed by a stopple *b*, and to the other end is attached a flexible tube *c*. For use, the bulb is introduced into the mouth, the open end nearly touching the veil of the palate, and the air inhaled through the flexible tube becoming charged with the medicament in its passage through the sponge. It is also adapted for nasal inhalation, one nostril being closed by the finger while inspiration is performed through the other.

This inhaler may be conveniently carried in the pocket.

The inhaler *B* (Fig. 2676) consists of a light conical frame-work of wire, having a soft cushion at the base and adapted to fit over the nose and chin, but not covering the eyes. A double cone of flannel is slipped upon this, over which is screwed a short tube having three branches equidistant from each other. This is covered by a cone of tin or other material impervious to ether, maintained in place by a nut screwing over the tube. For use, an india-rubber tube is drawn over the tube above mentioned, the other end of the rubber tube being attached to the neck of a bottle containing ether.

Tichenor's inhaler (*C*, Fig. 2676) is made of sheet metal in the form of a cylinder, surmounted by an inverted funnel. It contains an upper drawer *a* and a lower drawer *b*, in the former of which is placed the medicinal substance to be vaporized, and in the latter live coals or a piece of hot iron to effect this result. The top is connected with a tube *c*, the ends of which are of vulcanized rubber, and is provided with a mouth-piece *d*. The drawer *b* is left partially open during the generation of the vapor, admitting air which, passing through the perforated bottom of the drawer *a*, causes a draft through the funnel and serves to dilute the medicated vapor. This apparatus is also designed for anal and vaginal applications, the drawer *b* being closed and a hand-bellows attached to the tube employed to cause a draft.

The nitrous-oxide inhaler has two valves. One opens during the inspiration to admit gas from the reservoir to the lungs, and closes during expiration. The other valve opens during expiration to allow the effete air to pass off, and prevent its mixing with the contents of the reservoir. Thus a pure article is breathed at each expansion of the lungs.

Pilatre des Roziers invented an inhaler for enabling persons to enter places filled with deleterious gases; it consisted of a bag or case of leather or metal

charged with air under pressure; it was carried on the back, and provided with a flexible tube reaching around to the mouth of the bearer, and provided with an inwardly and an outwardly opening valve for inspiration and expiration. The nostrils were closed by a spring clamping the nose.

Galibert's apparatus is very similar to the above. Rouquayrol's apparatus, Fig. 2677, consists of a sheet-iron reservoir capable of bearing a pressure of 25 to 40 atmospheres; air is forced into it by a pump, the piston of which is fixed and the cylinder movable. Above is a bellows-like arrangement, which transmits the air to the tube leading to the nostrils of the operator, under merely the ordinary atmospheric pressure. A small two-leaved valve of india-rubber, kept closed by the external pressure of the air, opens to allow the escape of the air respired. This apparatus is carried on the back, like a soldier's knapsack. It is also used in submarine explorations.

Fig. 2677.

Rouquayrol's Apparatus.

In'haul. (*Nautical.*) A rope or purchase for rigging-in the jib-boom, studding-sail, or other spar.

In-jec'tion-cock. (*Steam-engine.*) The cock which closes the injection-pipe by which cold water is admitted to the cistern of the condenser.

In-jec'tion-con-dens'er. A cast-iron vessel of any convenient shape, and strong enough to bear the atmospheric pressure from without, in which the exhaust steam from the cylinder is condensed by a shower of cold water. The capacity of the condenser in Watt's original engines was $\frac{1}{8}$ that of the cylinder; but, according to present practice, it ranges from $\frac{1}{4}$ to $\frac{1}{2}$ of that of the cylinder, and sometimes even more. See CONDENSER; AIR-PUMP, etc.

See Burgh, "On Condensation of Steam" (London, 1871).

In-jec'tion-en'gine. (*Steam-engine.*) One in which the steam is condensed by cold water injected into the condenser. See CORNISH ENGINE; ATMOSPHERIC ENGINE.

In-jec'tion-pipe. (*Steam-engine.*) The pipe through which the injection water passes to the cistern of the condenser. In marine engines, the injection-pipe is open to the sea by a pipe which passes through the bottom of the vessel. See AIR-PUMP; CORNISH ENGINE.

In-jec'tion-syr'inge. (*Surgical.*) A syringe for administering douches or medicines.

c is the stand-pipe which rests in the bowl; *a* is the elastic air-bulb; *d*, the pipe; *e*, the nozzle.

f is Roosa's instrument for treating diseases of the middle ear. See Fig. 1814, p. 769.

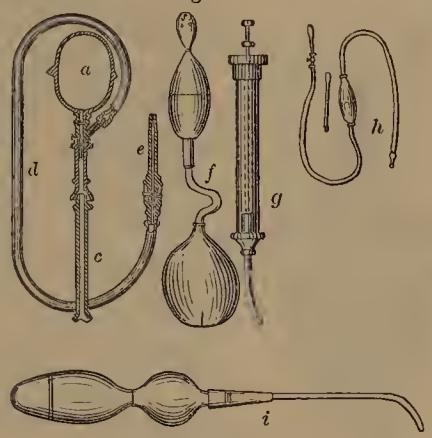
g is a self-injecting elastic syringe.

h is Tiemann's transfusion syringe.

i is an insufflator for blowing powder into the larynx or otherwhere. See INSUFFLATOR.

In-jec'tion-valve. (*Steam-engine.*) The one which governs the entrance of water into the condenser from the sea, river, or well.

Fig. 2678.



Injection-Syringes.

The area of the injection-valve of a marine steam-engine is stated at one square inch for every 10-horse power. This is said to be ample allowance in all cases, and is more than necessary when the injection water has a temperature of 52° Fah. The average temperature of the Mediterranean is about 65°; the Atlantic Ocean, at 20° of latitude, about 75°; and at the equator, about 82° Fah.

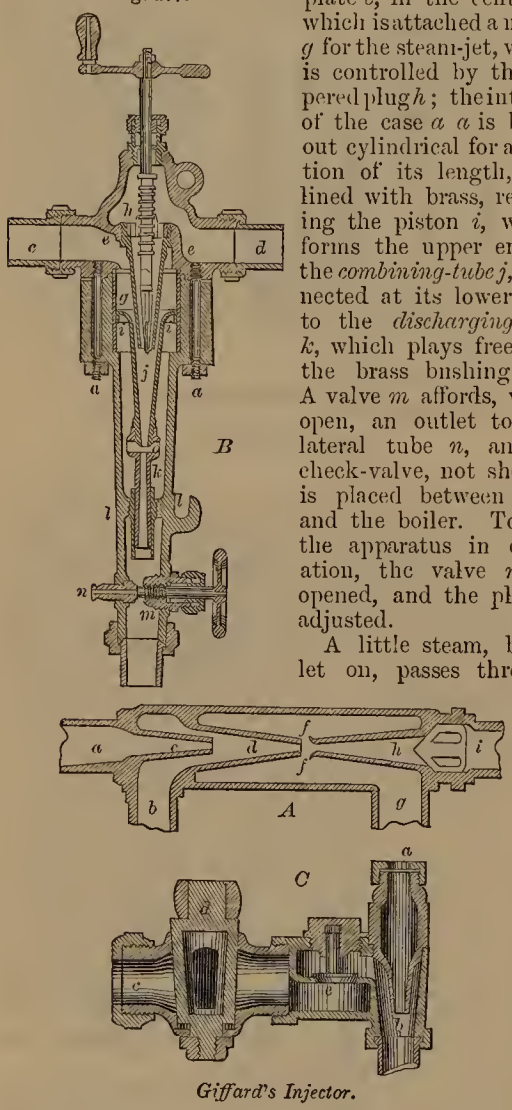
In-ject'or. A device for injecting a supply of feed-water into the body of a steam-boiler.

In Giffard's injector this is effected by the pressure and condensation of steam from the boiler itself. Fig. 2679, *A*, illustrates the operation of this apparatus. Steam escaping from the boiler through the pipe *a* is compelled to pass through the contracted nozzle *c*, by which its velocity is greatly increased. The feed-water from the pipe *b* is drawn into an annular space surrounding the nozzle *c*, and, mingling with the condensed steam, is driven through the pipe *h* and valve *i* into the boiler. Excess of steam or water, from want of proper adjustment, escapes through the outlet *f f g*.

The principle is as follows: Under a given pressure the velocity of escaping steam is much greater than that of the water which would be ejected were a hole opened in the boiler below the water-line. At a pressure of 90 pounds to the square inch, the excess of velocity of the steam is about in the proportion of 9 to 1. As the escaping steam, in being condensed, loses none of its velocity, except that due to the friction of the pipes through which it passes, it consequently, after condensation, has a penetrating force about nine times greater than the resisting force of the water in the boiler. At the moment of condensation it imparts its momentum to the water by which it is condensed, and with which it mingles. For instance, 1,700 cubic inches of steam on being condensed into one cubic inch of water imparts sufficient momentum to eight cubic inches of the water by which it is condensed to exactly balance the pressure of water in the boiler. In this case the opposing forces are in equilibrium; but combined with any less quantity of water, say seven inches, the momentum will more than suffice to overcome the resistance of the water in the boiler, and the mingled condensed steam and feed-water will force its way into the boiler, if a properly constructed entrance be provided for it.

Fig. 2679, *B*, shows Sellers' improved injector on the Giffard principle. *a a* is the outer casing in two parts united by bolts. It has two inlets, one *c* for water, and the other *d* for steam, separated by a

Fig. 2679.



Giffard's Injector.

plate *e*, in the center of which is attached a nozzle *g* for the steam-jet, which is controlled by the tapered plug *h*; the interior of the case *a a* is bored out cylindrical for a portion of its length, and lined with brass, receiving the piston *i*, which forms the upper end of the *combining-tube j*, connected at its lower end to the *discharging-tube k*, which plays freely in the brass bushing *l l*. A valve *m* affords, when open, an outlet to the lateral tube *n*, and a check-valve, not shown, is placed between this and the boiler. To put the apparatus in operation, the valve *m* is opened, and the plug *h* adjusted.

A little steam, being let on, passes through the small aperture in the steam-plug, creating a vacuum and causing the water to rise, when it is driven through the tubes *j k*, escaping at *n*. The plug *h* is then raised, increasing the flow of steam, and the valve *m* closed.

The action is as follows: The steam passing into *j* is condensed by the water from the water-supply tube, and the combined jet is driven through the discharge-tube *k*, and thence into the boiler.

If the water supply is in excess, a portion escapes by the opening *o* between the combining and delivery tubes, elevating the piston *i*, and contracting the annular space through which the water enters the combining-tube and limiting the supply. If the water supply is deficient, the velocity of the steam-jet is increased, a partial vacuum is formed in the chamber, and the piston *i* descends, enlarging the area of the water-supply space and permitting an increased flow. The apparatus is thus rendered self-regulating.

The injector *C* is used in the Westinghouse air-brake as an air-pump; the steam entering at *a*, and passing out as a jet at *b*, induces a current of air through the pipe *c* which leads from the cylinder beneath the car. (See BRAKE.) In this cylinder is the piston, which is mechanically connected to and works the brake-bars. *d* is a faucet which shuts off connection between the injector and brake-cylinder. *e* is an automatic valve which prevents reflux air through the pipe.

The injector has many other uses in the arts and manufactures: —

As an air and vapor pump it is applied to vacuum-pans, condensers of steam-engines, aspirators (by Bunsen), pneumatic dispatch-tubes (Siemen), etc. The well-known locomotive blast-pipe was an early application of the principle of the injector. (See LOCOMOTIVE; NOZZLE.) The action of these pipes was afterwards explained by Zeuner, and further results are due to Prüsman.

Gurney's steam-ventilator acted by means of steam passing through one pipe and sucking air through another connected with it. This simple apparatus was afterwards employed by Nagel and Kaemp in centrifugal pumps. Besides these may be mentioned Thompson's pump, the water-bellows, and Danchell's steam-manometer.

Ink. 1. A colored liquid or viscous material used in writing or printing.

The ancient ink was thick, and so is the modern Chinese. Demosthenes reproached Æschines with laboring in the grinding of ink as painters do in preparing colors. There is a difference between a *paint* and a *dye*, though the distinction is very imperfectly made out in customary language. A paint is smeared over an object, a dye colors or stains it. Some inks are of one kind and some of the other. The essential characteristics of the best ink are: limpidity, permanence, distinctness. The first enables it to flow easily and avoids clogging the pen. The second prevents its fading and becoming indistinct. The third makes it readily legible, both to the eye in following the motions of the pen, and to the eyes of readers subsequently.

An ink was found in an inkstand at Herculaneum. Some ancient manuscripts show the ink in relief when held to the light, and some have evidently been corroded by the ink.

Black ink is a solution of tanno-gallate of iron suspended in gum-arabic water. Logwood adds to the color. Take bruised galls, 6 ounces; gum-arabic, 4 ounces; green vitriol, 4 ounces; soft water, 6 pints. Boil the galls in the water, add the other ingredients; keep in a bottle, shake occasionally, and in two months' time decant into bottles and cork.

A drop or two of creosote or essential oil of cloves will prevent molding, or, as Dr. Gale remarked to an astounded Indianian, "will prevent the deposition of the ova of infusoria animalculæ."

He might have added, "and the sporadic growth of thallogenic cryptogams."

Such would probably be fatal to the fungi; the mere definition settled our brother from Indiana.

The addition of sugar to ink prevents sudden drying and makes *copying ink*.

Japan ink: Ribaucourt's recipe: aleppo galls, 8 ounces; logwood, 4 ounces; sulphate of iron, 4 ounces; gum-arabic, 3 ounces; sulphate of copper, 1 ounce; sugar candy, 1 ounce.

The galls and logwood to be boiled in twelve pounds of soft water until reduced to six pounds. Strain, and add the other ingredients. The ink dries with a gloss; hence its name.

Desormeaux recommends that the sulphate of iron be calcined to whiteness; coarse brown sugar instead of sugar candy; ¼ ounce of acetate of copper instead of 1 ounce of the sulphate; and agitation twice a day for two weeks before decanting and bottling.

Indelible ink. The addition of lampblack to ink will fortify it against the discharge of its colors by hydrochloric acid.

Close's recipe : copal, 50 grains ; oil of lavender, 400 grains ; lampblack, 5 grains ; indigo, 1 grain. Dissolve the copal in the oil by heat, and then add the coloring matter. Thin with oil of turpentine.

Sheldrake's recipe is a varnish, and is used for tombstones and marble : asphaltum or pitch, oil of turpentine, amber varnish, lampblack.

Red ink is a solution of alum colored with Brazil-wood ; or an ammoniacal solution of cochineal.

An indestructible red ink, or rather paint, consists of copal, 2 ounces ; oil of lavender, 14 ounces ; vermilion, 7 ounces.

Blue ink: sulphate of indigo dissolved in water to the desired tint.

Yellow ink: French berries, 8 ounces ; water, 1 quart ; alum, a small quantity.

Green ink: a mixture of blue and yellow.

Orange ink: a mixture of red and yellow.

Purple ink: a mixture of red and blue.

Brown ink: a mixture of black and yellow.

Sympathetic ink is an ink which is invisible till the writing is subjected to a subsequent operation, such as warming, exposing to sunlight or to a chemical reaction.

The ancients were acquainted with several modes. Ovid indiscreetly advises maidens to write with new milk. This, when dried, may be rendered visible by rubbing ashes upon it. Pliny suggests the milky juices of certain plants.

Modern chemistry has given us a number of recipes. Writing in the following solutions, subsequently dried, will be rendered visible by the means cited, developing certain colors.

Ink.	Treatment.	Color developed
Acetate of lead.	Liver of sulphur.	Brown.
Gold in aqua regia.	Tin in aqua regia.	Purple.
Infusion of galls.	Sulphate of iron.	Black.
Dilute sulphuric acid.	Heat.	Black.
Cobalt in dilute aqua regia.	Heat.	Green.
Precipitated oxide of cobalt in acetic acid and salt	Heat.	Blue.
Lemon juice.	Heat.	Brown.

Marking-ink is an aqueous solution of lunar caustic thickened with sap green and gum. It is written on a surface prepared by a weak solution of carbonate of soda and gum-arabic.

A *marking-ink* requiring no preparation of the surface is made of nitrate of silver, 1 ounce ; bi-tartrate of potash, 1 ounce ; solution of ammonia, 4 ounces ; archil, ½ ounce ; honey, 3 drachms ; tragacanth powder, 1½ drachms. When written, pass a hot iron over it or hold to the fire.

Marking-inks formed of a silver compound may be discharged by a solution of cyanide of potassium or a solution of corrosive sublimate, 1 ; sal-ammonia, 1 ; water, 100.

Lithographic ink for writing on stones, or for transferring autographically from paper : dry soap, 100 ; white wax, 100 ; mutton suet, 30 ; shellac, 50 ; mastic, 50 ; lampblack, 30. Incorporate with heat ; pour on an oiled plate ; cut into sticks, and use like India-ink.

Lithographic printing-ink resembles that for letterpress, but is ground up with burned linseed-oil, known as *lithographic varnish*.

Copperplate printing-ink is similar to that for letterpress, but is made of ivory-black or other fine quality.

Printing-ink is a smooth, jet-black oil paint, made of boiled linseed-oil, rosin-oil, or nut-oil, and lampblack ; soap and rosin are sometimes added.

Red and other colored printing-inks are made of linseed-oil boiled into a varnish, and with pigments of the required colors. Vermilion, Prussian blue, indigo, orpiment, chrome, red and orange lead, verdigris, etc. See Ringwalt's "Encyclopedia of Printing," page 226.

India-ink is a compound of lampblack and size ; formerly prepared from the pigment of the cuttle-fish.

Ink for zinc plant-labels: chloride of platinum, 100 grains, in a pint of water ; add mucilage and lampblack.

Or : sal ammonia, 1 drachm ; verdigris, 1 drachm ; lampblack, ½ drachm ; water, 10 drachms. Mix.

Fire-proof ink for use in writing or printing on incombustible paper consists of : powdered graphite, 22 drachms ; copal or other resinous gum, 12 grains ; sulphate of iron, 2 drachms ; tincture of nut-galls, 2 drachms ; and sulphate of indigo, 8 drachms. These materials are mixed together and boiled in water. This ink, which, besides being fire-proof, is said to be insoluble in water, under ordinary circumstances is black ; but when colored inks are desired, the graphite is replaced by an earthy or mineral pigment of the desired color.

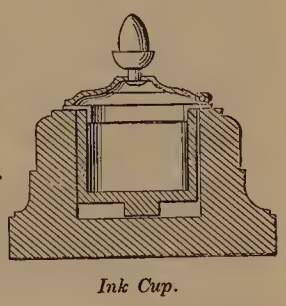
2. (*Machinery.*) The socket of a mill spindle. See STEP.

Ink-bench. (*Printing.*) An inking-table.

Ink-block. (*Printing.*) A block on which the ink is spread to be taken up by the balls or rollers.

Ink-cup. A dip-cup for ink. In the example, it is of rubber or glass in a wooden socket, and has a metallic flange and cup.

Fig. 2680.



Ink Cup.

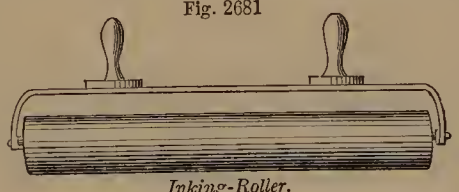
Ink-cyl'in-der. (*Printing.*) A cylinder rotating in the ink-fountain to bring the ink in contact with the *ductor* or fountain-roller.

Ink-foun'tain. (*Printing.*) The ink-reservoir of a printing-press from which the ink is taken by an ink-roller and passed to the *ductor*, or the distributing-roller.

Ink'ing-ap'pa-ra'tus. Different forms of apparatus have been adapted to different presses, and some of them are peculiar to the kinds. See list on page 226, Ringwalt's "Encyclopedia of Printing."

Ink'ing-roll'er. (*Printing.*) A roller which receives the ink from the inking-table and transfers it to the type in hand-press work. In power-presses, several rollers are employed, which are fed with ink

Fig. 2681



Inking-Roller.

from a trough, distributing it and transferring it to the inking-roller.

The composition of glue and molasses was invented by Donkin and Bacon (English patent, 1813). It is stated to have been previously used by one Edward Dyas of Madeley, Shropshire, England, who was indebted to an accidental overturning of his glue-pot to the suggestion of using the lump of semi-hardened glue.

Francis and Letmate's patent composition, June 21, 1864, consists of glue, 14 pounds ; glycerine, 28

pounds; castor-oil, 2¼ pounds; borax, 3 ounces; ammonia, 2 ounces; sugar, 7 pounds.

The endwise motion of the ink-distributing rollers is in the English patent of Professor Cowper, 1818.

The diagonal arrangement of the inking-roller, to give it a *relatively* endwise motion to the inking-table, is described in Applegath's English patent, 1823.

Ink'ing-ta'ble. (*Printing.*) A table upon which ink is spread to be taken up by the inking-roller.

The combination of inking-table, trough, and hand-roller was invented by Professor Cowper, and was described in his English patent, 1818.

In his printing-machine, the inking-table passed back and forth under rollers which received an end motion at the same time by means of an indentation along the edge of the table acting upon a frame in which the rollers were mounted.

In Applegath's English patent, 1823, the rollers are placed diagonally across the table and receive an end motion thereby.

Ink'ing-trough. The reservoir of ink from which the inking-roller is supplied.

In'kle. A broad linen tape. *Wrought* spinel. Spinel is bleached yarn for the manufacture of the tape, and is known as *unwrought inkle.*

Ink-print'ing Pro'cess. (*Photography.*) A process by which positive prints are obtained in common writing-ink. Immerse the paper in a solution of bichromate of potassa, in the dark. Expose under a negative. The picture will be brown on a yellow ground. Wash to remove the undecomposed chromium salt. Immerse in a weak solution of protosulphate of iron, wash; the iron salt will adhere to the image or mordant. Immerse in tannic acid; the picture blackens by the formation of tannate of iron. Wash and dry.

Ink-slice. A paddle for handling ink.

Ink'stand. A cup or bottle, from which ink is dipped with the pen.

Among the varieties may be cited: —

A, a fountain inkstand in which ink is raised in the dip-hole by depressing the piston in the reservoir. In a modified form a porcelain block is suspended in the ink and forces ink into the dip-cup by displacement.

B has an elastic caoutchouc ink-cup in a wooden case. The screwing down of the cover raises ink in the neck.

C. The raising of the lid elevates a little pan of ink to a convenient position for dipping.

D is a fountain inkstand with an overflow chamber closed by a plug.

E is a globular fountain inkstand, movable in a socket.

F is the ordinary fountain inkstand with metallic base, and pen-rack.

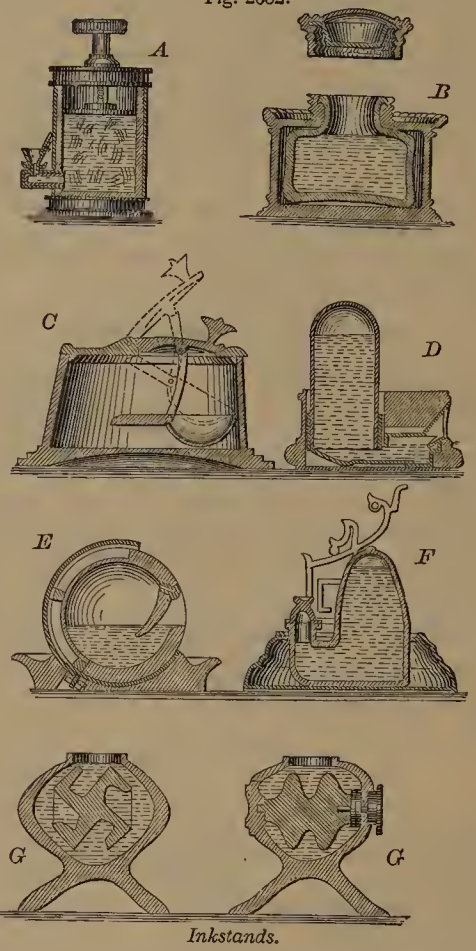
G G are two views of an inkstand having a glass disk containing four cups; rotation in one direction brings a cup of ink to be dipped from; in the other direction brings a solid portion of the disk to the aperture, and protects the ink from dust and evaporation.

The inkstands of the ancient Egyptians were of wood, porcelain, or other materials. Specimens are in Dr. Abbott's collection. They contain places for the red and black pigments, and also for the reed pens.

The inkstands of the Romans were round, square, or hexagonal; and single or double, the latter for red and black inks. A number were found at Pompeii.

The invertible inkstand is first shown in the English patent, No. 3407, November 25, 1869. It has a supplemental chamber and funnel above the usual center dip reservoir, to catch any ink which may pass out of the lower one in inverting. The present usual form is a center dip reservoir which latter has a lateral capacity sufficient to contain the

Fig. 2682.



Inkstands.

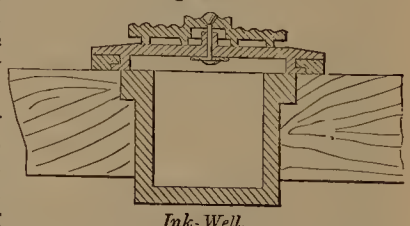
contents of the dip-basin when tipped on its side or inverted.

Ink-sur'face. (*Printing.*) The surface on which ink is distributed in a cylinder-press.

Ink-ta'ble. A flat-topped table on which ink is brayed or mulled ready for the inking-roller.

Ink-well. An ink-cup adapted to occupy a hole in a desk, its top letting down flush with the top of the desk, or nearly so.

Fig. 2683.



Ink-Well.

In'laid-work. That in which one material is sunk into a hollowing in the surface of another, the two making an even face. See Buhl; Reisner-work; Marquetry; Parquetry; Mosaic, etc.

In-lay'ing. A species of ornamentation in which choice woods, metal, ivory, mother-of-pearl, etc., are inserted within portions of groundwork which are sunken to receive them, thus forming a sort of mosaic.

We find specimens of inlaying of metals in the articles recovered from ancient Babylon.

Overlaying was practiced by the same people.

Herodotus states that "Glaucus the Chian" was

"the man who invented the art of inlaying steel." The salver made by Glaucus was offered by Alyattes the Lydian at the oracle of Delphi. It is described by Athenæus as "covered with representations of plants and animals." Alyattes was the father of Crœsus, who reigned till defeated by Cyrus, 556 B. C.

Under this head we may fairly refer to the Taj at Agra, the most beautiful building in the world. It is thus described by Sir Charles Dilke: —

"On the river bank [the Jumna], a mile from Akbar's palace, in the center of a vast garden entered through the noblest gateways in the world, stands the Taj Mahal, a terrace rising in dazzling whiteness from a black mass of cypresses, and bearing four lofty and delicate minars, and the central pile that gleams like an alp against the deep blue sky, — minars, temple, tomb, all of spotless marble and faultless shape. Its Persian builders named the Taj 'the palace floating in the air.'

"Out of the fierce heat and blazing sunlight you enter into chill and darkness, but soon begin to see the hollow dome growing into form above your head, and the tomb itself, that of Noor Mahal, the favorite queen of Shah Jehan, before you, and beside it her husband's humbler grave. Though within and without the Taj is white, still here you will find the walls profusely jeweled, and the purity retained. Flowers are pictured on every block in mosaic of cinnamon-stone, carnelian, turquoise, emerald, and amethyst; the corridors contain the whole Koran, inlaid in jet-black stone; yet the interior, as a whole, exceeds in chastity the spotlessness of the outer dome. Oriental, it is not barbaric. . . . . In a Persian manuscript there still remains a catalogue of the prices of the gems made use of in the building of the Taj, and of the places from which they came. Among those named are coral from Arabia, sapphires from Moldavia, amethysts from Persia, crystal from China, turquoises from Thibet, diamonds from Bundleeund, and lapis lazuli from Ceylon. The master masons were of Constantinople and Bagdad."

The varieties of inlaid work are numerous, and some of them very beautiful, bringing into use small fragments of valuable material that could hardly be applied to any other purpose. The principal varieties consist of *marquetric*, in which woods of a variety of tints are inlaid in the form of flowers and other ornamental devices.

Buhl, wherein metals are inlaid upon a ground of ebony or tortoise-shell. The German cabinets made of ebony, and inlaid with precious stones or various woods and metals, constitute a species of this kind of work.

Mosaic inlaying, composed of extremely small pieces. The Hindoos make very beautiful boxes in this style. At the London exhibition in 1851 a table produced in Spain was shown, composed of three millions of pieces. Many Chinese and Japanese works of bijouterie are also of this class.

Parquetric is a species of marquetrie on a bolder scale, applied chiefly to decorating floors, woods of different colors being cut to pattern and inlaid.

Pietra dura, consisting of certain kinds of hard stone, such as agate, jasper, chalcedony, carnelian, and lapis lazuli, inlaid in slabs of marble, generally black.

The marble is worked to a thickness not much exceeding one eighth of an inch, the design is drawn upon this, and is cut out with a fine saw and a file. The hard stones, worked into the required pattern by the usual modes of gem cutting, are accurately fitted into the spaces thus prepared, in a polished and finished state. After the whole is thus prepared, it is fixed as a veneer to a thicker slab.

Tarsia. This was formerly much practiced in Italy during the Middle Ages, and is now carried on in France and elsewhere. It is executed in woods of different shades, the figures comprising flowers, birds, and colored ornaments; the various parts being cut out to the required figure are then placed according to the design and fixed on paper; afterwards they are applied like veneers to a piece of furniture; being mounted, they are cleaned off and slightly polished, and the finer lines then engraved.

In-lay'ing-saw. A saw used in piercing stuff for buhl-work. See BUHL-SAW.

In'let. An opening into a drain or culvert.

In'ner-form. (*Printing.*) The form beginning with the second page of a sheet usually worked off first. In a quarto, it contains pages 2, 3, 6, 7.

In'ner-post. (*Shipbuilding.*) A piece brought in at the fore-side of the main-post, and generally continued as high as the wing-transom to seat the other transoms upon.

In'nings. (*Hydraulic Engineering.*) Lands recovered from the sea.

In-quar-ta'tion. (*Metallurgy.*) See QUARTATION.

In'sect-de-stroy'er. A device for killing noxious insects.

By *fumigation;* a bellows which drives poisonous fumes or vapors, such as those from sulphur, upon insects or plants.

By *dusting* sulphur upon them by means of a bellows and tube.

By *steam-jets.*

By *atomizers* which distribute coal-oil or turpentine in a fine spray.

By a *lamp*, which attracts nocturnal insects to singe their wings or allure them to a pan of water.

By *wire cages*, which imprison moths and worms which seek access to beehives. These are *traps.*

In'sect-trap. A device to catch insects upon or approaching an object.

Traps are set upon trees to catch the curculio. Such are frequently merely circular troughs around the stem. In some countries it is necessary to let the legs of tables, cupboards, and bedsteads stand in cups of water to prevent access of ants.

The moth-trap for beehives is a familiar instance, and consists of a wire cage which arrests them; or a lure to a box or pan, out of which they cannot get; or viscous smear which imprisons them; or a light which clips their wings.

In-sert'a-ble-tooth Saw. One with removable teeth. See SAW-TOOTH.

In-ser'tum-o'pus. A wall in which the stones are small and unhewn, similar to rubble-work. See MASONRY.

In'set. (*Bookbinding.*) Same as *offcut.* A certain portion of the printed sheet in 12mo, 24mo, etc., which is *cut off* before folding and set into the middle of the folded sheet, to complete the succession of paging.

In'shave. (*Coopering.*) A jointer having a convex-edged bit, on which the inner faces of staves are dressed.

In'side-cal'i-pers. A calipers for measuring bores and inside diameters of tubes. See CALIPERS.

In'side-cyl'in-der. (*Steam-engine.*) A cylinder placed in the smoke-box of a locomotive, to keep it warm; preventing the radiation of heat incident to the customary *outside* exposure.

In'side-fram'ing. (*Steam.*) *a.* The frame of one form of English locomotives, in which the wheels and driving-gear are inside of the main frame.

b. The stays of a locomotive-engine, that rest on the axles. The English practice is to have the

framing *outside* of the cylinders, the connecting-rods of the engines passing to cranks on the axles.

In'side-gear. (*Steam-engine.*) The English arrangement in locomotives of the pitmans and cranks inside the frame, in contradistinction to the American practice of connecting the cross-heads of the engines by pitmans to wrists on the outside of the driving-wheels.

In'side-screw. A hollow screw; one having its thread on the inside.

In'side Screw-tool. (*Lathe.*) A hook-shaped tool for threading interior surfaces while revolving in a lathe. A form of *chaser*. See Fig. 1256.

In'side-tin. (*Bookbinding.*) A plate laid inside the cover of a book when placed in the standing-press.

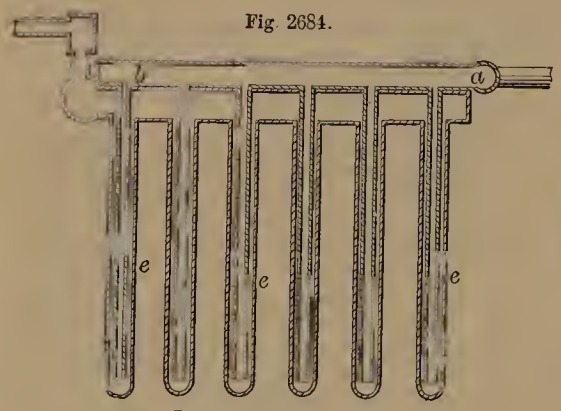
In'side-tool. (*Wood-turning.*) For hollowing out work and bottoming holes.

In'soles. A thickness of cork, felt, flannel, leather, paper, etc., placed inside a shoe to protect the sole of the foot, or to improve the fit of the shoe.

> "Suppose one 's short,—
> They put cork soles within the hecls of her shoes."
> ALEXIS; quoted by ATHENÆUS, A. D. 220.

In-stan-ta'ne-ous Gen'er-at-or. A form of steam-boiler or generator, in which a small body of water is injected at a time into a highly heated vessel, flashing into steam immediately. It differs from

Fig. 2684.



Instantaneous Generator.

ordinary boilers in there being no unvaporized water in the boiler. In most cases there is no steam-chest, and the theory has been to inject at each time a quantity sufficient for one impulse of the piston. The term *flashers* has been applied to this form of generators, from the fact that the jet of water instantly *flashes* into steam. Trouble has been found in the rapid corrosion, and in the cracking of the material of the boiler.

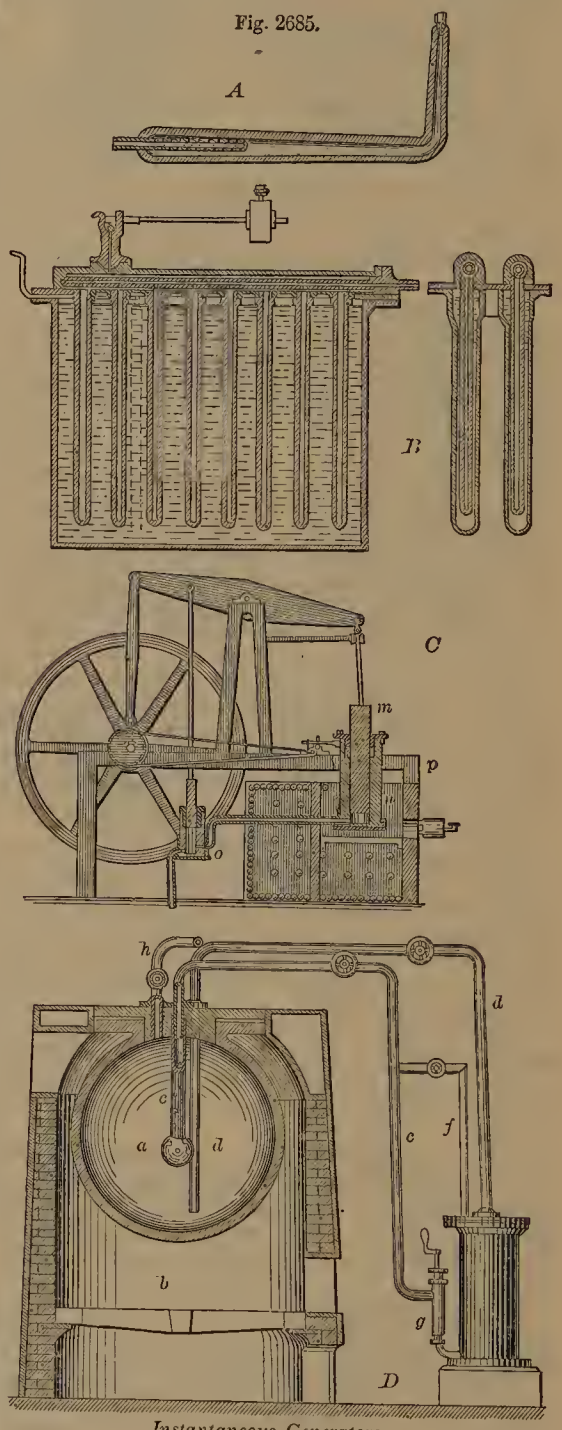
McCurdy's English patent (*A*, Fig. 2685), 1824, has a tube into which is introduced a smaller tube with perforations which deliver a fine shower into the outer tube, which is exposed to the heat of the furnace.

Dr. Alban, of Mecklenburg, patented, in 1825, a device (*B*, Fig. 2685) in which steam was generated in a series of strong vertical tubes, which are submerged for the greater portion of their length in a bath of molten lead. The row of vertical pipes was supplied by water trickling from a pipe above, somewhat as in Fig. 2684, in which, however, the water is conducted from the pipe *a b* by an inner tube down to the bottom of the pipe *e*, in which it is flashed into steam.

Jennings's steam-engine, 1828 (*C*, Fig. 2685), has a piston or plunger *m* which moves in a cylinder *n* when water is injected beneath it by means of the pump *o*. Means of escape for the expanded steam are afforded by a valve working on the frame *p* when the piston has completed its upward stroke.

In Danford's steam-generator (*D*, Fig. 2685) *a* is a spherical vessel, into which water is injected in a spray through pipe *c c* by the force pump *g*. *d* is a pipe through which superfluous water is blown off

Fig. 2685.

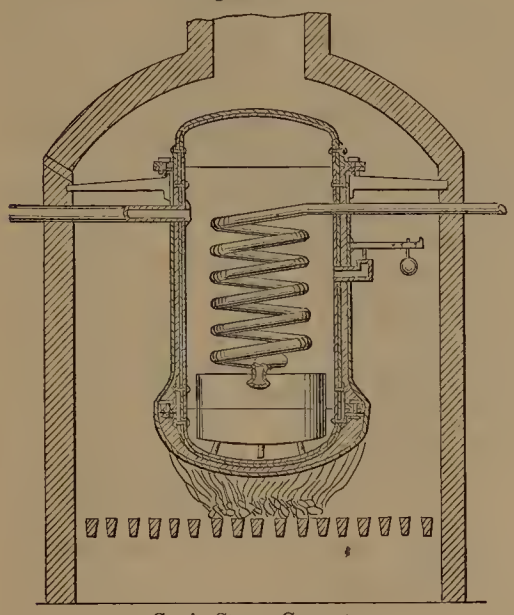


Instantaneous Generators.

back to the reservoir. *f* is a branch pipe leading back from the injection-pipe *c* to the reservoir, and by means of a cock such part of the water as may be desired is returned. It forms a means of graduating the amount injected. *b* is the furnace, and *h* the steam-pipe to the engine.

Fig. 2686 is a form in which a metallic cup extends upward from the lower and inner surface of the

Fig. 2686.



Case's Steam-Generator.

boiler to receive the water or steam thrown in by the feed-pump, and prevent sudden cooling of any part of the boiler.

In'step-stretch'er. A shoemaker's implement for distending the instep of a boot. The movable piece is elevated by a screw.

Fig 2687.

Instep-Stretcher.

In-suf-fla'-tor. An instrument for blowing burned alum or other powder into the larynx or other deep-seated part. See *i*, Fig. 2768.

In'su-lat-ed Col'umn. (*Architecture.*) One unconnected with any wall or building.

In'su-lat-ed Wire. 1. One suspended by insulators (which see) so as to prevent the electric current from going to *earth*.

2. One wrapped with silk or clothed with gutta-percha or caoutchouc to prevent the escape of the electric current.

Among the best insulators are dry air, shellac, sulphur, resins, gutta-percha, caoutchouc, silk, dry fur, glass. See INSULATOR; SUBMARINE CABLE; TELEGRAPH.

Among the materials prominently put forward for the insulation of wire, and forming by themselves or in various combinations the subjects of patents, are:

Animal substances.	Collodion.	Pyroxyline.
Asbestus.	Fiber.	Spun glass.
Ballata.	Gums.	Varnish.
Bituminous substances.	Kerite.	Vitreous coating.
	Paraffine.	Wax.

In'su-lat-ing-stool. A stool with glass legs to insulate a person or an object placed thereon.

In'su-lat-or. (*Electricity.*) A (so-called) non-conducting material; that is, one of relatively very small conductivity, placed between an electrified body and other objects. A device for supporting a wire or other conductor without affording a way of escape to earth of the electricity. It is sometimes of glass or porcelain, with the wire wrapped around it, or tied by wire to it.

The accompanying cut shows several kinds. *a* has a two-hooked head, around which the wire is lapped or wound. The shank is firmly socketed in a glass or vulcanite socket, which screws into the telegraph-post.

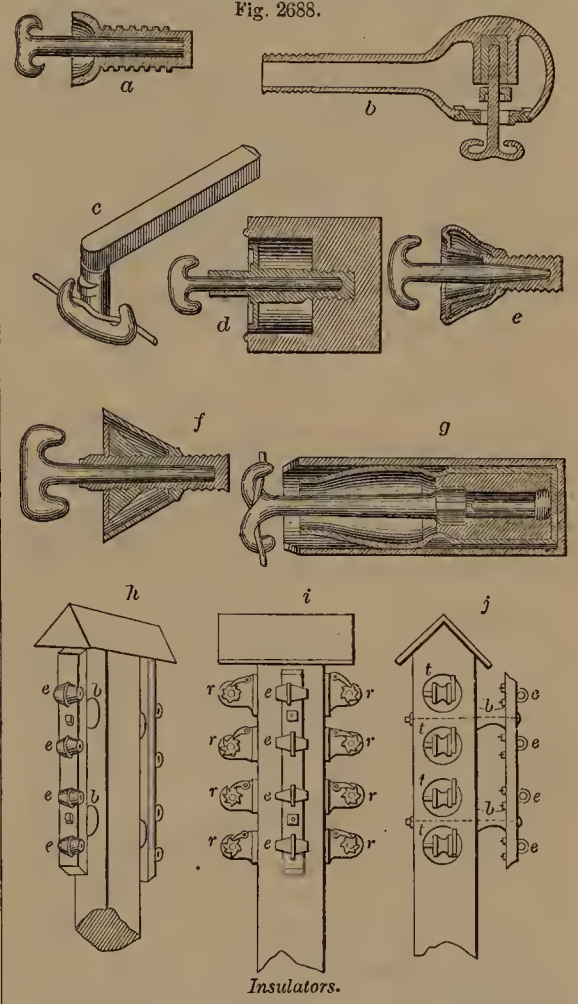
In *b* the inverted cup has a shank by which it is secured to the post, and a socket to hold the end of the pin; between the latter and the edge of the cup is an annular non-conducting disk.

c has a shank to enter the telegraph-post, and a two-pronged stem covered with vitreous enamel.

d has a flanged disk to prevent the accumulation of a film of moisture around the stem.

e, the metallic hook is socketed in a hard rubber-plug which enters the telegraph-post. A flaring cap

Fig. 2688.



Insulators.

is rooted to the insulator-plug, and its rim approaches the hook.

f has a bell around the disk on the rubber socket of the hook-shank.

g is Varley's insulator, which obtained the prize at the Paris Exposition. It has a paraffine cup and a conducting shield which conducts off atmospheric electricity.

h i j are three views of Cooke's insulator (English). *e e* are earthenware thimbles for the wires. *b b* are insulating earthenware struts. *r r* are winding ratchets for the reels *t t* on which the wires are strained. Posts at intervals of 400 yards.

All bodies are conductors of electricity; but while in some the degree of conductivity is so great that they are used to convey the electric fluid, others resist the passage of the current to such an extent that they are said to insulate, or confine the fluid to a more favorable medium. The following bodies ad-

mit the passage of electricity about in the order written : —

Silver.	Acids.	Oils.	Paper.
Copper.	Saline solutions.	Ashes.	Feathers
Gold.	Metallic ores.	Phosphorus.	Hair or wool.
Mercury.	Animal fluids.	Lime or chalk.	Silk.
Cadmium.	Water.	Caoutchouc.	Glass.
Zinc.	Vegetables.	Camphor.	Wax.
Tin.	Animals.	Porcelain.	Sulphur.
Iron.	Flame.	Dry wood.	Resin.
Lead.	Smoke.	Gases and air.	Amber.
Platinum.	Vapor.	Leather.	Paraffine.
Carbon.	Earths.	Lycopodium.	Shellac.
Graphite.	Metallic oxides.	Parchment.	Gutta-percha.

In-tagl'io. Cut in ; as of the lines in an engraved plate, the sunken letter in the matrix of a type, the design in a seal, punch, or die, which delivers a raised or *cameo* impression. The opposite of *cameo*.

In-tagl'io-type. A process allied to the graphotype and depending upon the production of a friable surface of oxide of zinc on a metallic plate under hydraulic pressure. Upon this lines are drawn with an oleaginous ink, the object of which is to repel a watery solution subsequently applied. A solution of chloride of zinc or analogous salt is washed over it and hardens the surface not protected by the oil. After drying, the surface is brushed over, and the bristles or velvet remove the oxide and ink, leaving an intaglio impression, from which castings may be made in the electro-bath or by stereotyping.

In-ten'si-fy. (*Photography.*) A term applied to various modes of giving strength or increased opacity to the deposit forming the photographic picture on an exposed and developed negative plate. It is frequently effected by continuing the development, using fresh quantities of "developer" and nitrate of silver ; also by converting the deposit of metallic silver already formed into new compounds having greater opacity. Sulphuret of silver and mercury and other substances are used.

In-ten'si-ty. 1. A term applied to indicate the energy of the magnetic force, which varies at different places and different times. It is one of the three elements of the magnetic force which are registered by the magnetometrical instruments of the chain of observatories in Europe, Asia, Africa, and America. The other two elements are the *declination* and *inclination*. See MAGNETOMETER.

2. (*Electricity.*) A term which expresses the electro-motive force of a current. An *intensity battery* is one in which the elements are coupled up together, to give a current known as *high-tension*, that is, of great electro-motive force. The term, as applied to a battery, is used in contradistinction to *quantity*.

In-ter-co-lum-ni-a'tion. (*Architecture.*) The distances between the columns composing an architectural front. These are regulated by the diameter of the column, being in —

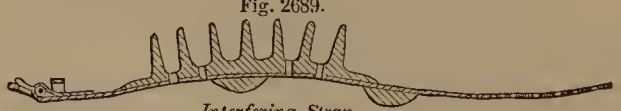
Aræostyle, from 4 to 5 diameters ; diastyle, from 3 to 4 diam.; eustyle, 2¼ diam.; systyle, 2 diam.; pycnostyle, 1½ diameters.

In-ter-den'tal. (*Machinery.*) 1. The space between teeth or cogs.

2. (*Architecture.*) The space between two *dentils*.

In-ter-fer'ing, At-tach'ment for. A device

Fig. 2689.



Interfering-Strap.

fastened to the leg or foot of a horse, to prevent cutting by collision of the feet or shoes. In the example, the rubber guards are attached to the padded strap, which is buckled round the horse's leg. See LEG AND FOOT GUARD.

In-te'ri-or Screw. One cut on an interior or hollow surface, as of a nut, burr, or tap-hole. A *hollow* or *socket* screw.

In-te'ri-or Slope. (*Fortification.*) The slope of the embankment from the crest inward toward the body of the place. See ABATTIS.

In-ter-leave'. (*Bookbinding.*) A book bound with alternating blank leaves, for notes, additions, translations of the text, etc.

In-ter-lig'ni-um. (*Architecture.*) The space between the ends of the tie-beams.

In-ter-me'di-ate Frame. (*Spinning.*) The second fly-frame ; an intermediate, in order of time, between the *slubbing* and the *roving* frame.

In-ter-me'di-ate Shaft. The shaft crossing the frame of a marine-engine, to connect the two engines and two paddle-wheels.

In-ter-mit'tent Gear. 1. A wheel having a part of its cogs cut away. A *mutilated* gear.

2. A wheel moved at intervals by a cog, cam, ratchet, rack, or lever ; as in counting-machines, meters, registers, escapements, etc.

In-ter-mit'tent Light. One of the characters of light exhibited from lighthouses under the catoptric system. The variations or different characteristics of lights enable a mariner coming within sight of them on a coast to determine his geographical position and bearings.

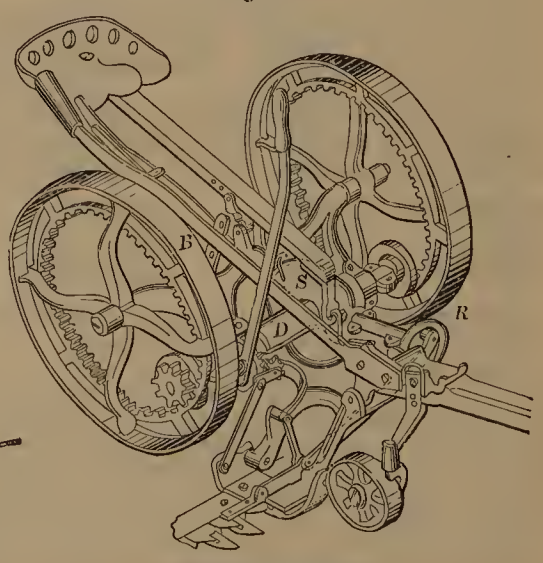
The *intermittent light* bursts suddenly into view, remains steady a short time, and is then eclipsed for half a minute. The effect is produced by the motion of shades in front of the reflectors, alternately displaying and hiding the light.

The other varieties of lights are : —

Fixed, revolving, flashing, colored, double, and these are variously combined. See LIGHT.

The *intermittent* and the *flashing* lights differ in respect of their modes of rising and fading, as also in their duration. The *flashing*-light gives a flash of light every five seconds, with intervals of dimness, the effect being produced by the revolution of a reflector frame with eight sides. The natural world affords several examples of light-carriers. The little fire-fly of the United States, whose common name is rather more than half sublime, *lightning*-bug, is an example of the *flashing*. The fire-flies of Italy and of South America, some species of nocturnal moths, and

Fig. 2690.



Internal Gear-Wheel.

the female glow-worm, have luminous patches on the head, sides of the thorax, or the abdomen. The light is considered phosphorescent, but is urged into activity by a nervous action, probably derived from voltaic impulse (as we call it) from the battery, the brain.

In-ter-mit'tent Wheel. This includes all the *escape-wheels;* counting wheels in meters, arithmometers, and registers; stop-motions in clocks and watches; ratchet movements, etc., etc. *See the above.* See also WHEEL; GEARING.

In-ter-mo-dill'ion. (*Architecture.*) The space between two modillions.

In-ter'nal Gear. A wheel whose cogs are on the internal perimeter, as in the example where the pinions on the shaft *D* are driven by engagement with the internal gear of the driving-wheels *B*. Inside the box *S* is a bevel pinion on shaft *D*, which turns a shaft on which is a wrist-wheel *R*, from which proceeds the pitman, which reciprocates the cutter-bar of the harvester.

Many agricultural implements have internal gear-wheels.

In-ter'nal Safe'ty-valve. (*Steam-engine.*) A valve opening inwardly into the boiler to allow air to enter when a vacuum is formed inside by the condensation of steam.

In'ter-nal Wheel. An annular wheel whose cogs are presented internally. See INTERNAL GEAR.

In-ter-ro-ga'tion, Note of. (*Printing.*) A sign (?) indicating a query.

In'ter-tie. (*Carpentry.*) *a.* A horizontal timber framed between two posts.

b. A binding joist.

In'ter-val. A space or distance, as a space between cogs, an *interdental* space.

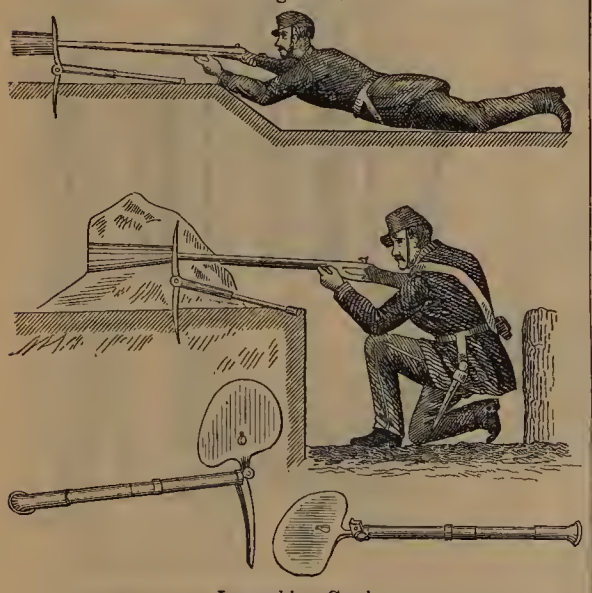
Between the frames in a military mine. A *bay.*

In-tra'dos. (*Architecture.*) The lower surface or *soffit* of an arch.

In-trench'ing Tools. Implements carried by the pioneers of regiments.

A combined spade and pick, invented by Captain Harrison of the London Military Engineers is shown

Fig. 2691.



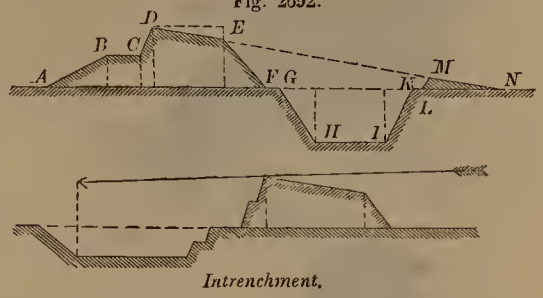
Intrenching-Spade.

in Fig. 2691. The spade and pick are hinged at their junction, to fit the tool for the respective uses. The embrasure is made by a roll of sheet-metal or bark, or a bundle of sticks tied up into a cylindrical shape. The spade has a hole for the barrel and sight.

In-trench'ment. (*Fortification.*) A defensive work consisting of a ditch, and a parapet made from the excavated earth.

The upper figure shows a profile of an intrench-

Fig. 2692.



Intrenchment.

ment, in soils of which the natural slope is one perpendicular to one base.

A B C D E F is the profile of the parapet.
G H I K the profile of the ditch.
L M N the profile of the glacis.
A B is the banquette slope.
B C tread of the banquette.
C D the interior slope.
D E the superior slope.
E F the exterior slope.
F G the berme.
G H the scarp.
H I the bottom of the ditch.
I K the counterscarp.
A the foot of the banquette slope.
B the crest of the banquette.
C the foot of the interior slope.
D the interior crest.
E the exterior crest.
F the foot of the exterior slope.
G the crest of the scarp.
H the foot of the scarp.
I the foot of the counterscarp.
K the crest of the counterscarp.
M the crest of the glacis.
N the foot of the glacis.

The lower figure shows a cover for troops, having an inner trench of sufficient depth, when aided by the hight of the parapet, to give shelter to troops when standing in the trench. The natural ground serves as the banquette.

In-vag'i-na-to'ri-um. (*Surgical.*) A douche for the vagina.

In'va-lid-bed. One having conveniences for the sick or the wounded, having elevating head and shoulder portion, to give the patient a change of position; a portion which conforms to the shape of the bended knees; conveniences for lifting the patient, introduction of a bed-pan beneath a removable section of the mattress, etc., etc.

In'va-lid-chair. A chair capable of assuming and retaining any required position from the erect to the prone. The figures illustrate the positions, the sustaining devices of the back, seat, leg-piece, and foot-stool being racks and screws. The one illustrated has a capacity for thirty changes.

The invalid-chair which has traveling arrangements is known as a *perambulator* or *locomotive-chair.*

In-vers'or. An instrument invented by Dr. Bird to reverse quickly a voltaic current.

In-vert'. 1. An inverted arch.

2. The floor of a canal lock-chamber. It is usually an inverted arch (convexity downward). See CANAL-LOCK.

In-vert'ed Arch. An arch whose crown is

Fig 2693.

Invalid-Chairs

downward. The *key-stone* being the lowest of the *voussoirs*, and the *springings* the highest. It is used in foundations, the floors of tunnels, etc.

Fig. 2694.

Inverted Arch.

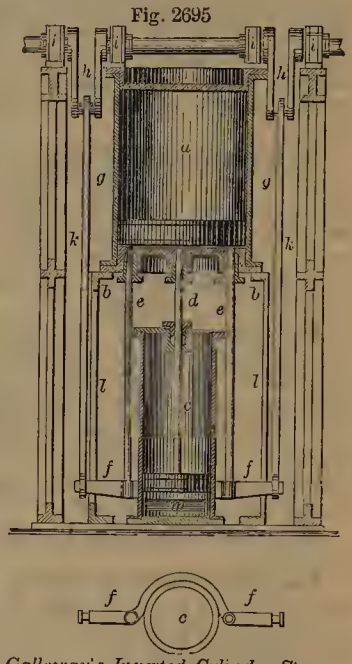
In-vert'ed Com'mas. A sign of the beginning of a quotation (" ").

"Age cannot wither her, nor custom stale
Her infinite variety."

In-vert'ed-cyl'in-der Steam-en'gine. Galloway's inverted-cylinder steam-engine is a form of direct-action engine, intended to obviate the use of the beam in marine engines.

a is the cylinder supported upon the frame or platform *b b*; *c* is the air-pump placed beneath the cylinder and concentric with it. The piston-rod *d* of the air-pump passes through a stuffing-box in the cover of the latter, and through another stuffing-box in the cover of the cylinder, and is attached to the steam-piston. Two piston-rods *e e* pass down through stuffing-boxes in the cylinder cover and are keyed to the cross-head *f*, which is curved so as to encompass one half of the air-pump. *g g* are two connecting-rods proceeding from the bearings of the arms of the cross-head to the crank *h h*. *i i* are the plummer blocks which carry the paddle-shaft; two of these are supported by the top of the cylinder, and the other two by the side frames *k k*. *m* is the neck in which is placed the foot-valve connecting the pump with the condensers. *l l* are the guides in which the cross-head *f* works.

Fig. 2695



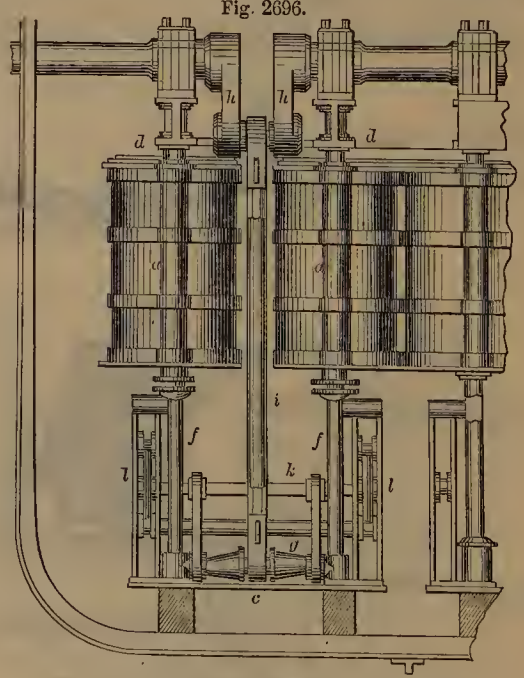
Galloway's Inverted-Cylinder Steam-Engine.

In-vert'ed Dou'ble-cyl'in-der Steam-en'gine. A form of steam-engine having two parallel cylinders, each of half the area necessary for the intended power, and combined to form one engine. The cylinders are inverted, being above the crank to which their piston-rods are directed. The four cylinders composing the pair of engines are ranged in a line across the vessel.

a a are the cylinders which stand upon strong iron columns (not shown) which rest on the foundation plate *c*, and, passing through suitable bosses on the sides of the cylinders, support the entablature plate *d* and the crank pedestals above. The cylinders are placed at a sufficient hight from the bottom of the vessel to allow the piston-rods to work downward. The two piston-rods *f f* are connected together by a cross-head *g*; the stuffing-boxes have self-acting oil-cups.

The power is transmitted directly from the main cross-head *g* below, to the cranks *h h* above the cylinders, by the connecting-rod *i*. The two piston-

Fig. 2696.



Hick's Inverted Double-Cylinder Steam-Engine.

rods *f f* and the cross-head *g* are made to work uniformly together by a strong vibrating cast-iron frame *k*, which forms part of the parallel motion, and with the side levers *l* serves also to work the air, feed, bilge, and brine pumps.

Each cylinder has its separate slide-valve in order that it may be nearer to the cylinder than it would be were one used for both. The condenser is not shown, but is beneath the slide-valve case, and the air-pump, foot-valve, and discharge-valve are similar in construction to those used in ordinary engines. The air-pump and condenser are connected by a passage beneath the foundation plate. The waste water is discharged from the hot-well by an overflow pipe through the side of the vessel.

The feature of the double cylinder is copied from *Maudslay's double-cylinder steam-engine*, but in the *Hick's engine* the cylinders are inverted, and the details of the connections are very different. This, like Maudslay's, is a *direct-action engine*, intended to obviate the use of a beam in *marine engines*.

In'ward-dis-charge' Wa'ter-wheel. A form of reaction water-wheel or turbine in which the water reaches the wheel from an outer encircling scroll and passes inward, discharging at the hollow center of the wheel.

I-rail. A double-headed rail with flanges on each side above and below; on the *foot* and *tread*. See IRON, ANGLE.

I'ri-an-kis'tri-um. A hook-shaped instrument used in the operation for artificial pupil by separation.

Ir-i-dec'tome. (*Surgical.*) A knife for operations on the eye.

A journal of February 1, 1801, gives an account of an operation performed by Citizen Demours of Paris upon a left eye, five sixths of whose cornea was perfectly opaque. "The only portion of the latter which remained pervious to light was on the upper part, and so high as to prevent any rays from passing thence through the pupil to the retina. To remedy this, the operation was conceived of cutting an opening through the pupil opposite to the luminous part of the cornea, which was accordingly performed by making a small orifice near the latter, large enough to introduce a very fine pair of scissors, with which a small slit was made in the iris. This opening being above the crystalline lens, and out of the sphere of its action, the patient is obliged to use very convex glasses in order to read, as those persons do from whom the crystalline humour has been extracted in the usual manner."

The Rev. W. H. Milburn gives the following account of the treatment of his eye by the famous oculist Professor Von Graefe of Berlin. The ophthalmoscope had been invented by Helmholtz five years, when, in 1856, Von Graefe, as Mr. Milburn says, "banished to the night of the past the blindness fatally attached to the glaucomatous eye." He relates that the Professor advised him to do without the chloroform, saying: —

"'There is only a slight transparent spot in the cornea into which I can cut; the merest muscular twitch, the deviation of the knife by the tenth part of a hair's-breadth, will ruin the operation; chloroform cannot hold you as steady as your will. What say you? I have confidence in your self-control.'

"I answered, 'Go on without the chloroform.'

"The eyelids were fastened back by springs, and the cutting proceeded.

"First, a linear incision was made through the cornea or colorless part of the eye, and a cut in the iris or colored part behind. Delicate forceps were then introduced to draw the iris out so as to line the new-made opening, and the edges of the iris, clipped with scissors, were skillfully fastened to the surface of the eye. Thus the operation for artificial pupil, called iridectomy, required in this case about four minutes and a half, — longer than usual, — and it can be well imagined that the time seemed much longer to me."

I-rid'i-o-scope. An optical instrument which shows the inside of the eye. Used to detect foreign substances and diseases.

I-rid'i-um. Equivalent, 99; symbol, *Ir.*; specific gravity, 22; nearly infusible.

It is a white, hard, brittle metal, more difficult to fuse than platinum, and the heaviest of all known substances.

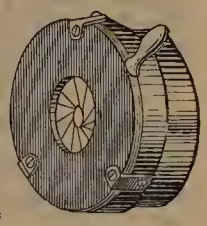
It has been used for forming the tips of gold pens.

The alloy of iridium and osmium, called iridosmine, is the hardest of all alloys. It forms the point of the "everlasting pen," made by Hawkins of England, and is ground by diamond-dust.

Ir-i-dos'mine. An alloy of iridium and osmium. The hardest of all known alloys.

I'ris-cope. An instrument contrived by Dr. Reade for exhibiting the prismatic colors. Sir David Brewster describes it in the "Phil. Trans." for 1841 as a plate of polished black glass, having its surface smeared with a solution of soap and dried by wash-leather. On breathing through a tube upon the glass, the vapor is deposited in brilliant colored rings.

Fig. 2697.



Iris-Diaphragm.

I'ris-di'a-phragm. (*Optics.*) A contractile diaphragm, simulating the action of the natural iris, to regulate the size of the aperture in a microscope through which light passes.

I'ron. 1. The most useful and abundant of the metals.

Equivalent, 28; symbol, *Fe.*; specific gravity, cast-iron, 7.2, wrought-iron, 7; fusing-point, 2,786° Fah. The ores principally worked are the oxides and carbonates, the metal in combination with oxygen, or with oxygen and carbonic acid.

The protoxide is an antidote for arsenic.

The peroxide is an ore, and is used as a pigment (ocher).

The loadstone is a magnetic oxide.

The bi-sulphuret (pyrites) is the bane of the gold and silver miner. Pyrites is now roasted for the production of sulphuric acid.

The protosulphate (green copperas) is used in dyes and inks; and calcined forms *crocus*, *rouge*, *cocothar*, for polishing.

The useful forms of iron are cast-iron, steel, and wrought-iron. The former two are compounds of iron and carbon, being carburets or carbides of iron. Cast-iron has the larger proportion of carbon in its composition. Wrought-iron is nearly pure iron, but it has generally some traces of carbon, sulphur, and phosphorus. The less the better, but the two last are hard to eliminate.

Iron was found, so says the chronicle, on Mount Ida, by the Dactyles, after the burning of the forest by lightning, at a period answering to our 1432 B. C. The Greeks claim the first discovery of it, of course. How many centuries it had been used in China, India, and Egypt can hardly be determined. Moses, who died 20 years before the era assigned, credits one with the invention who had been dead 2,000 years when he, the great lawgiver, wrote.

Chariots, axes, bedsteads, harrows, weapons of iron, are mentioned in Hebrew history between 1490 B. C. and 1040 B. C. Jeremiah and Ezekiel speak of iron, and mention two qualities, one of which the latter calls "bright iron," probably steel. The same distinction is made by Hesiod (850 B. C.).

Some doubts have been expressed as to the render-

ing of the Hebrew passage which speaks of Tubal Cain as an artificer in *iron*, and the passage which speaks of the *iron* bedstead of Og, King of Bashan, about 1450 B. C. The Arundelian marbles place the use of iron in 1370 B. C., and other authorities go back to 1537 B. C. These corroborate the iron bedstead of Og. Extremes meet, and we have lately revived the use of the material first recorded as used for that purpose. Moses mentions an iron furnace 1490 B. C., and Job speaks of iron as "taken out of the earth."

Gold, silver, and copper, and alloys of the last, were, no doubt, used before iron, and it would be reasonable to expect that such would be the case, as they are so readily obtained by simple metallurgic operations, while iron is more refractory.

The existence and uses of iron among the ancient Egyptians are pretty well proved by the paintings, in which the iron or steel knives and sickles are distinguished from the bronze by the color; one being blue, the other a reddish-brown.

In Dr. Abbott's collection, now in the possession of the New York Historical Society, are the following articles of iron, stated by the doctor to be of undoubted authenticity. They were found at Thebes:—

Iron helmet, neck-guard, and breast-plate of scale armor, with the name of Shishak, who invaded Judea 971 B. C.

An iron spatula, iron arrow-head, warrior's flail with iron studs, and some emblematic articles of iron.

The ancient iron mines of the Egyptians have been lately discovered by English explorers. The process was wasteful, and the slag contains 53 per cent of iron. The sites are in the vicinity of Mt. Sinai, and it is proposed to work over the *débris* of the former workings.

Of the first use of iron in Egypt, Wilkinson says, we have no certain record. His surprise at the execution of the sculptures is very natural, but he does not appear to have estimated the character of the alloys of copper and tin, some of which are very hard. (See ALLOY; BRONZE.) Belzoni discovered an iron sickle-blade beneath a granite sphinx at Karnak. Colonel Vyce found an iron blade imbedded in the great pyramid. Layard found a steel cross-cut saw, and other articles of iron, at Nimroud; the saw is now in the British Museum. The butchers of Thebes and Memphis had steels slung from their belts. At Babylon the stones of the bridge across the Euphrates, built by Nitocris, were cramped by bands of iron set in lead. Thucydides says the blocks of the walls of the Pireus were fastened in the same way. Theseus, who ascended the throne of Athens 1235 B. C., was buried with a bronze sword and spear. Some have dated the use of iron in Greece at 1406 B. C., but Hesiod makes it later. Homer generally speaks of bronze arms, but mentions iron.

We learn from the "Iliad" that at the time of the siege of Troy (1184 B. C.) iron was used in making axes, shipwrights' tools, axles for chariots, plow-points, sheep-hooks, and some other agricultural implements. "As the smith plunges the loud-hissing axe into cold water to temper it, for hence is the strength of iron," etc., shows clearly that the writer or compiler of the "Odyssey," whom we are content to call Homer, lived in a time when iron and steel were forged and tempered.

About 500 B. C., and thereafter, steel was imported into Greece from the Chalybes, a people inhabiting the shore on the southeast of the Black Sea, and the use of bronze for weapons terminated soon after. Marathon was fought 460 B. C. The steel was called Chalybian, and we retain the name in connection with waters, as Chalybeate springs.

In Asia the Chalybes were noted for their works in iron, from which they obtained great profits. — XENOPHON, *Anab.*

Aristotle mentions that their arenaceous ores were washed, and he also partially describes the operation of making wootz in India; Diodorus Siculus says that in the island of Ethalia the ores were roasted and broken fine before melting. It was *wrought*-iron that was produced and employed, and not *cast*-iron, which is a comparatively recent production, and it is probable it was all obtained, by a primitive direct process, from rich and easily reducible ores.

The early means for the reduction of iron from the ore were small furnaces with cold blast, in which rich ore was heated in contact with incandescent charcoal, the viscid mass being hammered to remove earthy impurities. This plan is yet practiced in India, Africa, Malaya, Madagascar, and forms the

"Mass of iron, shapeless from the forge,"

offered by Achilles as a prize at the funeral games of Patroclus, recorded in Homer's twenty-third book of the "Iliad."

Dr. Livingston refers to the iron-smelting furnaces of the tribes encountered in his "Expedition to the Zambesi." The articles produced by these peoples are hammers, tongs, hoes, adzes, fish-hooks, needles, and spear-heads.

King Porus presented to Alexander the Great a wrought bar of laminated steel, for which Damascus was subsequently so famous that it is known as Damascene. One of the most remarkable forgings in the world, if it be one, is the wrought-iron pillar within the precincts of a mosque near Delhi. It is a shaft with a capital 22 feet high above ground, and a greater length below. Its probable weight is over 38,000 pounds. It has an inscription in Sanscrit, which records that it was erected by King Dhava of the Hindoo faith.

The character of the Sanscrit inscription, according to the English linguists of Hindostan, indicates a period at about A. D. 400. See FORGING.

The examples cited from the writings of Moses, Hesiod, and Homer, the attestation of the recovered implements from Egypt and Nineveh, and the Egyptian paintings, render it useless to cite the facts within the notice of the gossiping and credulous Pliny, who professes to give the early history of the metal. Palestine, Asia Minor, Scythia, Elba, and Spain were each celebrated in their time for the production of iron. From Iberia the art spread to Gaul, and from the latter, probably, to Germany.

An army of Gauls was defeated by the Romans, 222 B. C., chiefly because the swords of the former bent after a blow or two, and required straightening by the foot, while the superior metal of the Romans stood the brunt.

Strabo mentions that one of the exports of Britain was iron; the bold islanders met their invaders with scythes, hooks, broadswords, and spears of iron.

The arrival of the Romans and the introduction of artificial blast, which the Romans had derived from their Eastern neighbors, gave a great impulse to the iron works of England.

Under Adrian, A. D. 120, a fabrica or military forge was established at Bath, in the vicinity of iron and wood.

During the Roman occupation of England, some of the richest beds of iron ore were worked, and the *débris* and cinders yet exist in immense beds to testify to two facts: one, that the amount of material worked was very great; the other, that the plans

adopted were wasteful, as it has since been found profitable to work the cinder over again.

During the Saxon occupation the furnaces were still in blast, especially in Gloucestershire.

The early Norman sovereigns were so intent upon skinning the Jews and the Saxons, that it became dangerous to succeed in any business, success being an invitation to the barons to plunder. Accordingly, we find in the time of King John that iron and steel were imported from Germany.

The business lumbered along for some centuries, the government tinkering at it now and again, the exportation being prohibited in the fourteenth century, and the importation of iron in the fifteenth century.

The direct method of obtaining wrought-iron from the ore prevailed until the commencement of the fifteenth century, but then gradually gave way to a less direct process, but one more convenient when handling large quantities. Blast-furnaces, operating by the aid of strong blast, to *melt* the iron and obtain *cast-iron*, which is carbureted in the process, were in use in the neighborhood of the Rhine about A. D. 1500. A second process in a *forge-hearth* was used to eliminate the carbon and other impurities, and the result is *wrought-iron*. The *puddling-furnace* was invented more than 250 years afterward.

In the sixteenth century (1590), we find a notice of a mill for slitting iron into bars for smiths' use by Godfrey Bochs.

The change from the use of wood coal to that of mineral coal was only accomplished in England after a great many futile attempts.

In the reign of Elizabeth, blast-furnaces were of sufficient size to produce from two to three tons of pig-iron per day by the use of charcoal. In the small works, the iron was made malleable before being withdrawn from the blast-furnace, and in larger works was treated by the refinery-furnace.

Wood becoming scarce, and a number of furnaces having gone out of blast, in 1612, Simon Sturtevant was granted a patent for thirty-one years for the use of pit-coal in smelting iron. Failing in his proposed plans, he rendered up his patent the following year.

The patent was granted in 1613 to John Ravenson, who also failed, and resigned his patent, which was again and again granted to succeeding inventors and adventurers who believed themselves possessed of the means and knowledge for accomplishing the object.

In 1619 the patent came into the hands of Dudley, who at the age of twenty left Oxford University to take charge of his father's furnaces at Pensnet, in Worcestershire, and who succeeded in producing three tons of iron per week in a small blast-furnace by the use of coke from pit-coal. The parties who yet possessed plenty of wood, and with whom the production of iron was fast becoming a monopoly, urged the charcoal-burners to destroy the works of Dudley, which was done. Dudley's patent was granted for thirty-one years, which would bring it to 1650, the time of the Protectorate, when England had a ruler fit to succeed Queen Bess. The celebrated statute of King James, limiting the duration of patents to fourteen years, was passed in 1624.

From the circumstance that Dudley petitioned Oliver Cromwell and Council for a renewal of the term, two things are evident: one, that he had pursued the scheme and anticipated or had achieved success; the other, that the limitation of his patent from thirty-one to fourteen years had not been enforced or had been revoked. Dudley charges that the extension of his term was refused by the influence of favorites of the Protector, who wished to share in his profits, and on his refusal defeated his application for extension.

It is likely that Dudley only received a moderate remuneration for his pains, as no one seems to have taken any interest in the business after it was thrown upon the public by the expiration of his patent. Iron of poor quality continued to be made in districts where wood was scarce, and of good quality from charcoal in places where the forests yet remained. The demand for iron continuing to grow, — a natural effect of advancing civilization, — iron was exported from Sweden and Russia in large quantities and of excellent quality. The forests of these countries gave them a natural advantage over England, whose woods had by this time become thinned out, so that the use of wood for iron smelting had been forbidden by act of Parliament in 1581, within twenty-two miles of the metropolis, or fourteen miles of the Thames, and eventually was forbidden altogether.

The art of making iron with pit-coal, and of casting articles of iron, was revived by Abraham Darby, of Colebrookdale, about 1713, and was perseveringly followed, although it was but little noised abroad. In the Philosophical Transactions for 1747 it is referred to as a curiosity.

Certain parties had attempted to smelt iron in clay pots exposed in a furnace, resembling that used for glass, to the flame of a pit-coal fire, expecting to procure the iron by tapping the pots. The scheme, which might have answered with a more tractable material, failed in the case of the iron ore.

Tinning of iron was introduced from Bohemia in 1681.

The extension of the iron manufacture dates from the introduction of the steam-engine, which increased the power of the blast, and the blowing engines driven by manual, horse, or ox power were superseded by engines. The dimension of the blast apparatus was increased from time to time, and about 1760 coke was commonly used in blast-furnaces. In 1760 Smeaton erected at the Carron works the first large blowing cylinders, and shortly after Boulton and Watt supplied the steam-engines by which the blowers were driven. Peter Onions, in his patent of 1783, described the *rationale* of the puddling process; and Henry Cort, of Gosport, in 1784, made it practicable, and added grooved rolls, by which the puddled bar was drawn. Neilson, of Glasgow, introduced the hot blast in 1828. Aubulot, in France, in 1811, and Budd, in England, in 1845, heated the blast by the escaping hot gases of the blast-furnace. The Calder works, in 1831, demonstrated the needlessness of coking when hot blast is employed.

Experiments in smelting with anthracite coal were tried at Mauch Chunk in 1820, in France in 1827, and in Wales successfully by the aid of Neilson's hot-blast ovens in 1837. The experiment at Mauch Chunk was repeated, with the addition of the hot blast, in 1838, 1839, and succeeded in producing about two tons per day. The Pioneer furnace at Pottsville was blown July, 1839.

The first iron-works in America were established near Jamestown, Virginia, in 1619. In 1622, however, the works were destroyed, and the workmen, with their families, massacred by the Indians. The next attempt was at Lynn, Massachusetts, on the banks of the Saugus, in 1648. The ore used was the bog ore, still plentiful in that locality. At these works Joseph Jenks, a native of Hammersmith, England, in 1652, by order of the Province of Massachusetts Bay, coined silver shillings, sixpences, and threepences, known as the "pine-tree coinage," from the device of a pine-tree on one face.

Of the special processes for treating and purifying, a few may be cited : —

Smelting by blast with charcoal, pit-coal, and coke, and with the addition of limestone or shells as a flux, have been noted. See *supra ;* also BLAST-FURNACE.

Puddling and *boiling*, somewhat similar operations for burning the carbon of pig-iron and eliminating other impurities, are considered under those heads. See also DECARBONIZING-FURNACE ; REDUCING-FURNACE ; MALLEABLE IRON ; BESSEMER PROCESS ; FORGE, etc. See list under METALLURGY.

Steel processes are considered under STEEL. See also BESSEMER PROCESS ; CONVERTOR ; CEMENTATION-FURNACE, etc.

A process for decarbonizing molten cast-iron by applying an air-blast in the hearth of a blast-furnace was invented by C. Shunk.

Kelly patented in the United States, in 1857, a mode of decarbonizing molten crude cast-iron by running it into a cupola or vessel, separate from that in which it was melted, and blowing through it from the bottom a blast of air, so as to burn out the excess of carbon, — the blast being strong enough to furnish rapid combustion of the carbon, and thereby retain the temperature and fluidity of the molten metal until sufficiently refined, without the use of other fuel.

Bessemer worked as an original inventor in the same line, and much improved the process in general and in detail. Holley gave it its American form. See BESSEMER PROCESS.

The process of decarbonizing the molten iron by addition of manganese is found in Reynolds's English patent, about 1800.

Mushet's patent consisted in the introduction of manganese or other highly oxidizable metals, during the process of melting the crude iron, for the purpose of detaching and removing oxidized substances.

Krupp uses spiegeleisen.

Schmit, of the Troy Bessemer works, recommends ferro-manganese in small quantities and in solid pieces, as a recarburizer.

Clay's process of making wrought-iron direct from the ore (English, 1843) consists in sifting rich ground ore, mixed with $\frac{1}{10}$ weight of coal, into the chamber of a furnace where it is puddled and balled ; after this it is shingled and rolled in the ordinary manner.

Jameson's process consists in exposing the calcined and crushed ores in a series of deoxidizing chambers, where it is exposed to the heat of the burning gases which come from the furnace below. It is pushed from the floor of one chamber to another, and in the last chamber is exposed to hydrogen generated by the decomposition of a jet of steam injected upon it to aid in ridding it of sulphur and phosphorus. Thence to the charcoal bed and refining chamber, where the *loop* is formed, and whence it is taken to the hammer.

Henderson's process for the manufacture of iron-steel (patents, 1870) embraces the use of fluor-spar and titaniferous ores, and treating crude ores by fluorides and oxides.

The Ellershausen process consists in the conversion of crude cast-iron into wrought-iron by the admixture of granulated iron ore, a layer of molten iron, and a sprinkling of powdered ore, alternating in molds. These blooms are put in a reverberatory, puddled, squeezed, and rolled.

Bessemer has patented in England a mode of applying to the decarbonization of iron, nitrates, chlorates, and other salts, which evolve oxygen when heated.

By Blair's process, patents Nos. 126, 923, 924, 925, of 1872, the oxides of iron are subjected, in contact with solid carbon for a certain time, to a uniform red heat, the access of other oxygen during the process being prevented. By this means the oxygen leaves the iron and unites with the carbon, passing off in a gaseous state, while the iron remains, being reduced to a metallic state as iron sponge. The metallic iron thus obtained is, however, in a very sensitive condition while hot, and in that state absorbs oxygen with great avidity ; but, if cooled before being brought into contact with the atmosphere, it does not readily re-oxidize.

After reduction, the iron sponge retains the shape of the ore from which it is derived, but somewhat expanded in bulk, and with very marked loss of weight. It has a spongy texture ; is readily sectile ; is easily indented by the finger-nail ; chews like lead between the teeth, and polishes quickly to a silvery luster. Its color, unless influenced by some coloring matter accidentally present in the ore, is grayish,

Fig. 2698.

Angle, Bar, Girder, and Rail Irons.

varying from blackish to a clear lead-color. When powdered and burned in the open air it sparkles brilliantly, as does iron burned in an atmosphere of oxygen.

Taylor describes a method of making cast-iron from oxides of iron by reducing magnetic iron ores

to powder and separating the iron oxides therefrom by magnets, and preparing and uniting the same for use in the furnace.

See STEEL. Also, and much better, see Percy's "Metallurgy, Iron and Steel," London, 1864.

2. An instrument or utensil of iron.

A *box-iron*, *flat-iron*, *smoothing-iron*, *sad-iron*, or

Fig. 2699.

Angle, Bar, Girder, and Rail Irons.

Italian-iron is a form of heated instrument for smoothing damped clothes, starched or otherwise.

The *iron-heater* is a piece of metal or wire heated in the fire and placed in an urn, *box-iron* or *Italian-iron*, to heat it.

The *iron-holder* is a pad upon the handle to protect the hand; or is a ring or tripod to stand the iron upon temporarily.

Tailors' and *hatters'* irons are forms of smoothing-irons adapted to the uses of the said operatives. A tailor's iron is known as a *goose*.

A *plane-iron* is the bit or cutting portion of a joiner's plane.

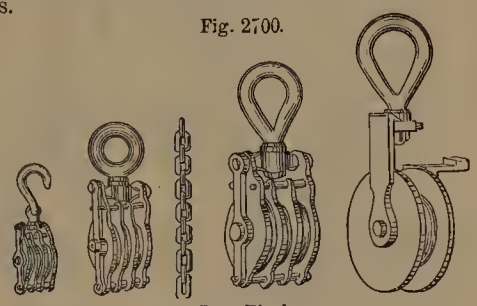
3. The iron portion of a thing, as a *boom*-iron, or *pump*-iron; a *clip* of a single-tree; the *plow*-irons, the iron portions of a plow, etc.

I'ron, An'gle, etc Figs. 2698 and 2699 show forms of rolled iron for bridges, girders, beams, rails, etc.

See Brandt's "Eisen-Konstructionen," Berlin, 1865; Heinzerling's "Die Brücken in Eisen"; Fairbairn's "On the Application of Cast and Wrought Iron," London, 1854; Zorè's "Recueil de Fers Spéciaux," Paris, 1853; and Maurer's "Die Formen der Walzkunst und das Façoneisen," Stuttgart, 1865. See also ANGLE-IRON.

I'ron-block. A tackle-block with an iron shell and strap. The illustration shows several kinds and sizes.

Fig. 2700.



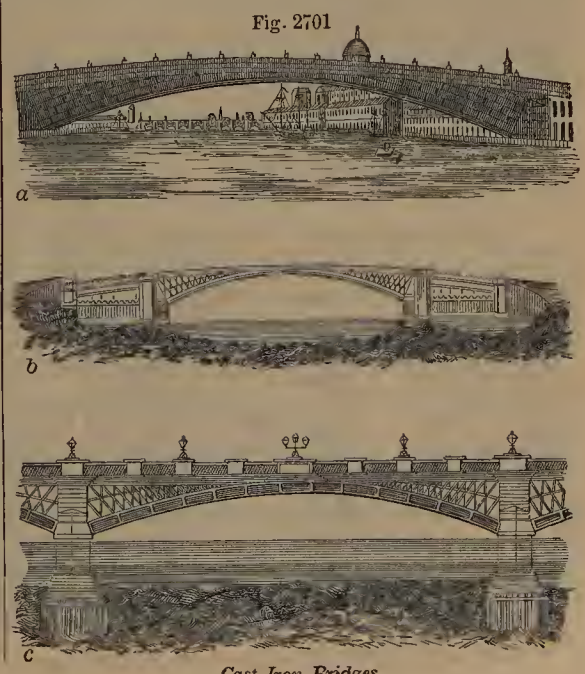
Iron-Blocks.

I'ron-boat. One made of iron-sheets, riveted together.

I'ron-bot'tle. An iron bottle with a screw-plug, for holding quicksilver. It is made by swaging and drawing from a disk of tough wrought-iron. After being brought by swaging to the form of an open-ended cylinder, it is put on a steel mandrel and driven through holes of decreasing dimensions till it becomes a long cylinder. The neck is pressed and twisted into shape and fitted with a screw-stopper.

I'ron-bridge. Iron-bridges were first used in China. — DU HALDE.

Fig. 2701



Cast-Iron Bridges.

Iron-bridges are of many forms: cast-iron arches, lattice, truss-girders, arched beam, or arch and truss, tubular girder, tubular arch, suspension. These are most of them considered under these separate heads.

The first built in England was an arch of cast-iron sections, erected in 1779 over the Severn, at Coalbrookdale, Shropshire, England, by Abraham Darby and John Wilkinson. It had five ribs, each cast in two pieces, secured where they join at the crown of the arch by a cast-iron key-plate, and connected together horizontally and vertically by cast-iron braces, formed with dovetails and forelocks. The ribs are covered with cast-iron plates, and the railing to the sides was of iron.

Dimensions of some of the principal Cast-Iron Bridges.

Date.	Place.	River.	No. of Spans.	Span. Feet.	Rise. Feet.	Weight. Tons.	Architect.
1779	Coalbrookdale	Severn	1	100.5	45	378 5*	Darby & Wilkinson.
1795	Buildwas	Severn	1	130	27	173.9*	Telford.
1796	Sunderland	Wear	1	240	30	260*	Wilson.
1818	Southwark †	Thames	3	240‡	24	5,308*	Rennie.
1836	"Carrousel"	Seine	3	187	15.5		Polonceau.
1859	Tarascon	Rhone		204 4	16.6		
1854	St Petersburg	Neva		150	13.8		
	New Blackfriars	Thames	5	185§	17		
	Georgetown Aqueduct ‖	Rock Creek	1	200	20		Meigs.

* English tons of 2,240 pounds.
† *c*, Fig 2701.
‡ And two side arches of 210 feet span each.
§ And four spans of 155, 175, 175, 155 feet; roadway and sidewalk, 75 feet wide.
‖ Two cast-iron pipes having a water-way of 42 inches, arched in form, carrying the roadway and forming conduits for the water supply of Washington.

In 1801 Telford proposed a cast-iron bridge (*a*, Fig. 2701) of 600 feet span across the Thames, and one of 500 feet span across the Menai Straits (*b*, Fig. 2701) in preference to the suspension-bridge of 570 feet span erected by him.

Other forms of iron-bridges involve the use of wrought-iron, as in the examples *a*, *b*, *c*, Fig. 2702, which are combinations of the arch and truss.

a is known as the rectangular tubular arch bridge.

b, iron-arch and lattice-girder bridge.

c, strut girder bridge.

d. The Kuilinburg bridge over the Leck, an arm of the Rhine, in Holland. It has nine spans; the principal truss shown in the cut is 515 feet in length, clear span 492 feet, depth in center 35.6 feet; at ends, 26.24 feet; weight of iron, 2,193.94 tons (English). Total length of bridge, 9 spans, 2,181 feet; total weight, 4,490.14 tons (English); clear roadway, 26.25 feet; double railway track.

e is a truss bridge over the Avon in England, the center resting on a cluster of screw-piles.

Dimensions of some of the principal Wrought-Iron Bridges.

Date.	Place.	River.	No. of Spans.	Widest Arch. Span.	Widest Arch. Rise.	Character.	Architect.
				Ft. In.	Ft. In.		
1850	"Britannia"*	Menai Straits	4	458 3	29 3½	Tubular	Stephenson.
1860	Plymouth	Hamoaze		433 6	30 6	Tubular	Brunel.
1855	Boyne	Foyle		250	32 6	Lattice	McNeil.
1858	Montreal *	St. Lawrence		330	31 8	Tubular	Stephenson.
1867	Cologne	Rhine		313	31	Lattice	
1861	Dirschau	Vistula		398	40	Lattice	
1874	St. Louis †	Mississippi	3	515	51 5	Tubular arch	Eads.
1866	Kuilinburg	Leck	9	515‡	Level.	Lattice	Michaëlis.
	Louisville §	Ohio	29	400	Level.	Truss	

* See TUBULAR BRIDGE.
† Two side arches of 497 feet each. See TUBULAR-ARCH BRIDGE.
‡ Clear span of main truss, 492 feet; also one span of 262 feet; seven of 187 feet each. See *d*, Fig. 2702.
§ Whole length, 5,294 feet; weight of iron, 8,723,000 pounds.

The iron truss-girder bridge over the Tay, a short distance west of Dundee, is somewhat over two miles long. From the north side the bridge rises by a gradient of 1 in 73 to the summit level, where the roadway is 88 feet above high water. The descent to the south side is 1 in 363. The thirteen spans of 245 feet each, in the centre of the river, form nearly one-third of the length of the bridge.

The Girard Avenue Bridge, Philadelphia, is shown on the opposite page. It crosses the Schuylkill River at the entrance to the Fairmount Park, and was built by the Phœnixville Bridge Company. The bridge is 100 feet wide; the frame is entirely of iron, the flooring being iron joists covered with corrugated iron plates and asphate concrete, and granite blocks laid in cement.

I'ron-cham'ber. (*Puddling.*) That portion of the puddling-furnace in which the iron is worked. The *reverberatory-chamber*, *charge-chamber*.

I'ron-clad Ves'sel. One having the exposed portion of the hull protected, in whole or in part, by a covering of iron.

At the siege of Gibraltar in 1782, the French and Spaniards employed floating batteries, made by covering the sides of ships with junk, rawhides, and green timber to the thickness of seven feet, and bomb-proofing the decks. The largest of these vessels was 1,400 tons burden; their armament was 32-pounders, and they were manned by 500 men. They had furnaces for heating shot. These vessels were finally set on fire by red-hot shot. In 1813, Fulton constructed a steam floating-battery for the United States.

The first application of iron for this purpose was by the French, during the Crimean war in 1855, to gunboats. These had a displacement of about 2,000 tons, were 172 feet in length, 43 feet beam, and 17 feet deep, protected by 4½-inch plating, and mounted 16 guns, all of which could be fought on one side. They were frequently struck by shot, but received no severe injury. The English at the same time built gunboats very similar in size and construction. As far back, however, as 1842, Mr. Theodore R. Timby had invented an iron-plated turret, adapted either to ships or fortifications. See MONITOR; TURRET.

The civil war of 1861 gave a great impetus to improvements in iron-clad vessels; the success of the monitors inducing the governments of Europe to engage extensively in the construction of iron-clads, the tendency being constantly to increase the thickness of the armor.

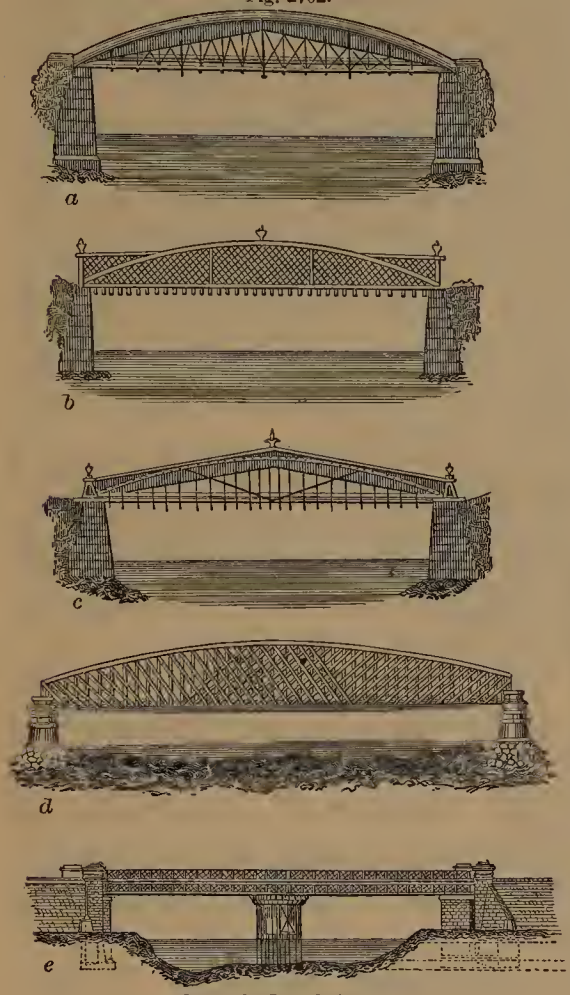
Iron-clad vessels are of the monitor or turret class, carry guns merely in broadside, or have the two systems combined.

The iron-clads employed by the United States on the Western rivers during the late civil war were mainly river steamers, the sides above the water-line placed at an

GIRARD AVENUE IRON BRIDGE.

PLATE XXVIII. OVER THE RIVER SCHUYLKILL, PHILADELPHIA, PA. *See page* 1200.

Fig. 2702.



Wrought-Iron Bridges.

angle of about 30°, and plated with 2 to 4 inches of iron, backed with 3 feet of oak. They carried 4 to 16 guns, and some of them were made to float in 2½ feet of water. They were calculated to fight "bow on," and were practically invulnerable to 100-pound shot when in this position. The "Benton," "Essex," "Carondelet," "Lexington," and a large number of others, were of this construction. Toward the latter part of the war a number of monitors were built for service on the Mississippi.

A class of vessels plated with ¾-inch iron were jocularly called tin-clads. Their armor was a protection against rifle-balls, but was easily penetrated by shells from the lightest field-pieces.

Improvised iron-clads, consisting of river steamers plated with railroad-iron, were used by both parties on the Mississippi. They were simply makeshifts, but in some cases were found to be quite formidable.

The "Galena" was one of the first three sea-going iron-clads built for the United States government, the "Monitor" and "New Ironsides" being the other two. The "Galena" was a two-masted vessel, 1,000 tons, 300 horse-power, and pierced for 18 guns. Her armor was of overlapping corrugated plates, from 2½ to 4½ inches in total thickness, backed by 18 inches of oak and walnut. In service she was found not to resist shot much heavier than 64 pounds at short range, and she lost many men in her first attack on Fort Darling.

The "Monitor," Ericsson's first iron-clad, was a vessel of about 1,000 tons, 172 feet long, 41 feet beam, 9 feet depth of hold, the deck about 2 feet above the water-line, and overhanging the hull some 6 feet on the sides and 20 feet astern. Under this "overhang" the screw worked. The deck, and the sides for 6 feet below the water-line, were plated with five inches of iron, in one-inch plates, breaking joints. The turret amidships was a round box of iron, built up of inch plates to 20 feet in diameter, 9 inches thick, and 9 feet high, with a grating or covering of railway bars. It contained two 11-inch guns. Her defeat of the "Merrimac" in Hampton Roads, March 9, 1862, rendered this little craft historic. She foundered in a storm, off Hatteras, December 31, 1862. See MONITOR. See also ARMOR-PLATING, p. 152.

The "Ironsides," completed at Philadelphia in 1862, was the only formidable side-gun iron-clad ever put in service in the United States. She was 240 feet long, 58½ feet beam, and rated 3,250 tons, 1,600 horse-power. She was plated with solid plates 4½ inches thick, and carried eighteen very heavy guns, sixteen 11-inch guns, and two 200-pounder rifles. She was found to resist all but the very heaviest shot at the closest range, thus proving the superiority of solid over laminated armor. She was struck more than 70 times in one day, and several hundred times in all, while serving in front of Charleston, but was never seriously injured. She was, unfortunately, burned at the wharf in Philadelphia, 1865.

The "Dunderberg" is an inclined armor broadside ship, of 7,000 tons displacement. Her armor consists of 3½ and 4½ forged iron plates, over a timber backing of from one to six feet. She was built in New York by W. H. Webb, Esq. The contract price was $1,400,000. She was sold by permission of Congress to the Emperor of the French for $3,000,000, having cost much more than was anticipated.

The "Roanoke" is an old United States wooden ship-of-the-line, cut down to near the water-line, plated with 4½ inches of iron, and has three turrets, 11 inches thick, each carrying two 15-inch guns. She was only used for harbor defence, being found to roll so much as to be almost unseaworthy.

The "Merrimac" was a United States wooden ship-of-the-line, and was set on fire at the Norfolk Navy Yard when that place was abandoned at the breaking out of the war. The hull was raised by the Confederates, and a false deck put on, above which an iron-clad fort was built, the sides sloping upward at an angle of about 30°. She carried ten heavy guns, some of them rifled 100-pounders. Her first engagement, March 8, 1862, showed her to be more than equal to a fleet of wooden vessels, she having sunk the "Cumberland" and crippled the "Congress" in a few hours. She was defeated next day by the "Monitor," and blown up two months later to escape capture.

The "Atlanta" was an iron vessel cut down, plated with two thicknesses of 2-inch iron plates over heavy wooden backing. She was captured by the monitor "Weehawken," June 17, 1863, having been disabled at the fourth shot from that vessel.

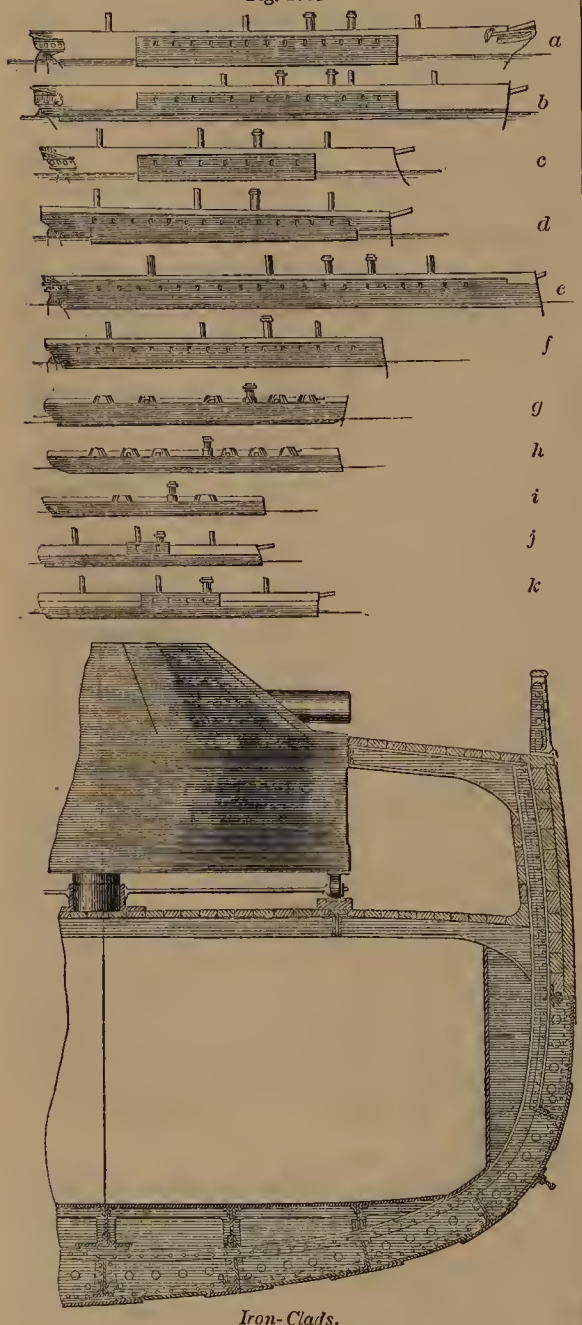
Most British iron-clads are built on the broadside principle, the "Captain," built something on the monitor plan, having foundered in a moderate sea, carrying down all on board.

The "Lord Clyde," said to be the fastest English iron-clad, is 280 feet long, 59 feet beam, 21 feet draft, 4,067 tons burden. The cylinders of her engines are 116 inches diameter, having 4 feet stroke. The boilers, nine in number, have brass tubes 2½ inches in diameter, with an aggregate heating surface of 19,000 square feet.

On her trial trip a speed of 13½ knots per hour was attained.

The "Hercules," launched in February, 1868, is 325 feet long, 59 feet beam; tonnage, 5,662; draft, 24½ feet when fully equipped. Her ram is a solid mass of iron, weighing 5 tons. She has 5 water-tight bulkheads. The iron plating is from 6 to 9 inches thick, the former thickness extending the entire length of the vessel to several feet below the water-line. This is backed by 10 inches of teak, 1½ inches

Fig. 2703.



Iron-Clads.

of iron, 20 inches more of teak, and ¾ inch of iron. The engines, of 1,200 nominal horse-power, are capable of being worked up to 7,000 horse-power. The weight of iron used in construction of the vessel is stated at 9,520,000 pounds; of wood, 1,814,400 pounds.

The thickness of armor-plating has been greatly increased since its first introduction; thus the "Warrior," built in 1861, has plating 4½ inches thick, that of the "Bellerophon" is 6 inches, and that of the "Hercules," as already stated, 9 inches. The French have increased the thickness of their plating to 15 centimetres, about 6 inches; and the "Marengo" and "Ocean" have plating 20 centimetres, or nearly 9 inches, in thickness.

Plates for experimental purposes have been rolled 15 inches thick, and it is claimed that plates of sound and uniform quality can be rolled 10 inches thick.

To resist the attacks of iron-clads the British government is erecting at Spithead two forts, plated with 15-inch iron. Each fort is 700 feet in circumference, 230 feet in height, and is armed with two tiers of guns, one consisting of twenty-four 600-pounders, and the other of twenty-five 400-pounders. The two will command the only deep channel leading from the sea to Portsmouth Harbor. The estimated cost of each fort is about £1,000,000 sterling. See ARMOR-PLATING.

Fig. 2703 shows broadside views of a number of English iron-clads, and is introduced to illustrate the modes of arming and of protecting; the shaded portions indicating the partial protection only, afforded in some instances to the battery and engines, and at about the water-line.

a shows the "Warrior" and "Black Prince" class of 6,039 tons.

b, the "Achilles," of the same size.

c, the "Defence" and "Resistance," 3,668 tons.

d, the "Hector" and "Valiant," 4,063 tons.

e, the "Northumberland," "Minotaur," and "Agincourt," 6,621 tons.

f, the "Prince Consort," "Royal Oak," "Royal Alfred," "Ocean Triumph," and "Caledonia," 4,045 tons.

g, the "Royal Sovereign," 5-turreted vessel, 3,765 tons.

h, the "Prince Albert," 6-turreted vessel, 2,529 tons.

i, a two-shield ship of 1,385 tons.

j, the "Enterprise," 990 tons.

k, the "Favorite," 2,186 tons.

The lower portion of the figure is a midship section of a British iron-clad ship of 1,385 tons, carrying two of the shields as adapted by Captain Coles of the British service. He was unfortunately drowned in the "Captain," which capsized off Cape Finisterre. The turret is shown as rotating on a central axis, and a circular system of anti-friction rollers. The conical portion only of the shield is exposed above deck, and the bulwarks are made hinging, so as to be thrown down when in action. The ribs, floors, iron-plating, and backing are also clearly shown.

The "Glatton," a modified monitor on Captain Coles's plan, was subjected to experimental firing by the British government to determine whether, by the impact of a 600-pound shot propelled by a 12-inch rifled gun, this turret could be jammed or prevented from working. There was also to be ascertained the probable damage that might be caused to the guns and other interior fittings of the turret.

The armor-plating of the latter, against which the shot was to be thrown, consisted of, first, one rolled covering of iron fifteen inches in thickness, disposed in two tiers, and secured to the backing and inner skin by bolts. Behind this armor-plating there is fourteen inches of teak, then an inner skin formed of two ¾ inch iron plates.

The gun used was one of the 25-ton 12-inch muzzle-loading Fraser guns, made at the Woolwich Arsenal. The projectiles selected were the Palliser 600-pound shot, solid and chill-headed, and the powder charge was 85 pounds large pebble. The vessel carrying the gun, the "Hotspur," was moored at a distance of 200 yards from and on nearly

a parallel line with the "Glatton." In the turret of the latter, a kid, a rabbit, and a fat hen were placed to try the effects of concussion.

The first shot which struck, took the turret armor in its weakest part, in the center of the turret-wall, upon a bolt-head and upon the lower edge of the upper 14-inch armor-plate. It lifted the upper plate until its lower edge was separated from the upper edge of the lower plate to a distance of 2½ inches, the upper edge of the lower plate, where the shot penetrated, being depressed nearly one inch by the sheer downward force of the shot.

The fracture extended upward from the plate's lower edge in a three-quarter-circle form, measuring 17 inches vertically and nearly 20 inches along the plate's edge. Inside the turret, the inner end of the bolt struck by the shot was found to have driven in and fractured the inner skin or iron lining, its nut breaking off and lodging upon one of the trunnions of the starboard gun.

The depth of penetration was 15 inches. Still, with all the immense striking force of the shot, estimated at a little over 6,100 tons, there was no through penetration, and the turret was found to revolve with the same facility as before the shot was fired. None of the gun fittings or gear were injured in any way. The kid, the rabbit, and the hen looked dazed, but they had sustained no other injury.

The German navy has the following iron-clads: "King William," 345 feet long, 58½ feet beam, covered with 8-inch iron-plates and 20 inches of elastic wood; it has 23 guns. "Prince Frederick Charles," 282¼ feet long, 52¾ feet beam, protected by 5 inches of iron and 15 inches of elastic wood cushioning; carries 16 guns. "Crownprince" is 277¾ feet long, 48½ feet beam, covered with 4½ to 5 inches of iron and 10 inches of elastic cushioning; bears 16 guns. "Arminius" is 194 feet long, 35 feet beam, covered with 4½ inches of iron and 9 inches of cushioning; bears 4 guns. "Prince Adalbert" is 154 feet long, has 4-inch iron-plates, 8 inches of cushion, and carries 3 guns. The last two ships are monitors. The guns are all of heavy caliber.

The Russian sea-going turret ship "Peter the Great" is 329 feet 8 inches length between perpendiculars. Her greatest outside breadth is 63 feet. The builders' measurement is 5,352 tons, and the displacement, with coal, stores, and water in boilers, will be 9,665 tons, at a mean draft of 23 feet 9 inches. The plates on the ship's sides and on the raised building amidships vary from 12 to 14 inches, and the armor-plate protects the ship to a depth of 6 feet below the water-line. The vessel has no spur, but the upright stem is heavily plated and of enormous strength. The ship has two large turrets, which are plated with 16 inches of iron in two thicknesses of 14 and 2 inches. She has no masts, but depends entirely on her compound engines, which were built at St. Petersburg. Each engine is of 700 horse-power, and connected with 2 four-bladed screws. There are 12 boilers, which will require at full speed 132 tons of coal in 24 hours; and at this rate of consumption the engines will work at 10,000 effective horse-power, and the ship will be driven at 14½ knots speed per hour. If the engines are worked at the second grade of expansion, she will have coal for 17 days, steaming 12½ to 13 knots per hour.

With the single exception of the teak-wood backing, all the materials of the ship, engines, and armament were produced in Russia, by Russian workmen.

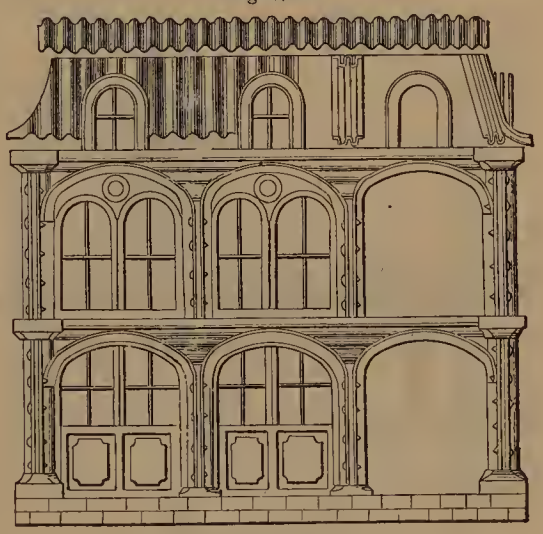
A round vessel invented by the Russian Admiral Popoff is 100 feet in diameter, plated with 9 inches of iron, and propelled by six screws on the part which may, by courtesy, be called the stern. A turret amidships carries two guns, which are fired *en barbette*. Below the water-line the vessel is divided into a large number of water-tight compartments.

I'ron, Cor'ru-ga-ted. Corrugated iron is used in many structures, — houses, sheds, cars, carriages, boats, tanks, etc.

As a covering for buildings it was first used as a roof for the Eastern Counties Railway Station at the London terminus, 1840. The plan is rectangular, with three aisles 230 feet long. The middle aisle 36½ feet wide, the side aisles 20½ feet. The iron is No. 16 wire gage, $\frac{1}{14}$th of an inch. The curve of the arch is at right angles to the corrugation. The sheets are riveted together in the direction of their length. The water follows the curves of corrugation to the gutters, which lead it to the posts; these are hollow, and conduct it to drains beneath the pavement.

Corrugated iron is in extensive use for buildings in countries deficient in wood, especially in some of the English colonies in the southern hemisphere;

Fig. 2704.



Corrugated-Iron House.

for railroad stations, exhibition and temporary buildings, warehouses, railroad freight cars, fire-proof floors, partitions and roofs, gutters, window-shutters.

Fig. 2704 is an elevation of a house made of corrugated sheet-metal upon an iron frame.

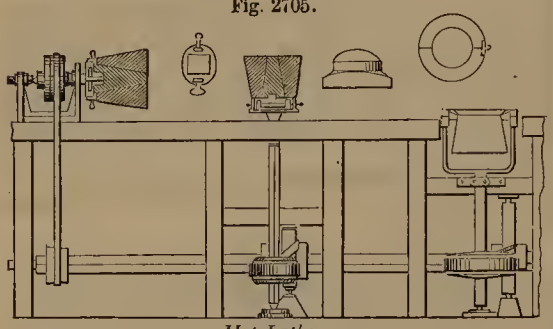
I'ron-fur'nace. (*Metallurgy.*) A furnace in which iron ore or the metal is exposed to heat. The purposes and construction are various. The subject is treated under the different heads: BLAST, REDUCING, DESULPHURIZING, DECARBONIZING, PUDDLING, FURNACES. See list under METALLURGY.

I'ron-ing-board. (*Domestic.*) A laundry implement on which clothes are ironed; sometimes having a special shape, as for bosoms, pantaloons, etc.

I'ron-ing-lathe. (*Hat-making.*) A machine having mandrels carrying blocks on which hats are mounted for ironing. The different blocks and positions shown are for holding the hat while the side, crown, and outside and inside of the brim respectively are ironed.

I'ron-ing-ma-chine'. One for ironing clothes, etc. Specific forms are make for hat-ironing, for hosiery, and for tailors. The example shows one

Fig. 2705.



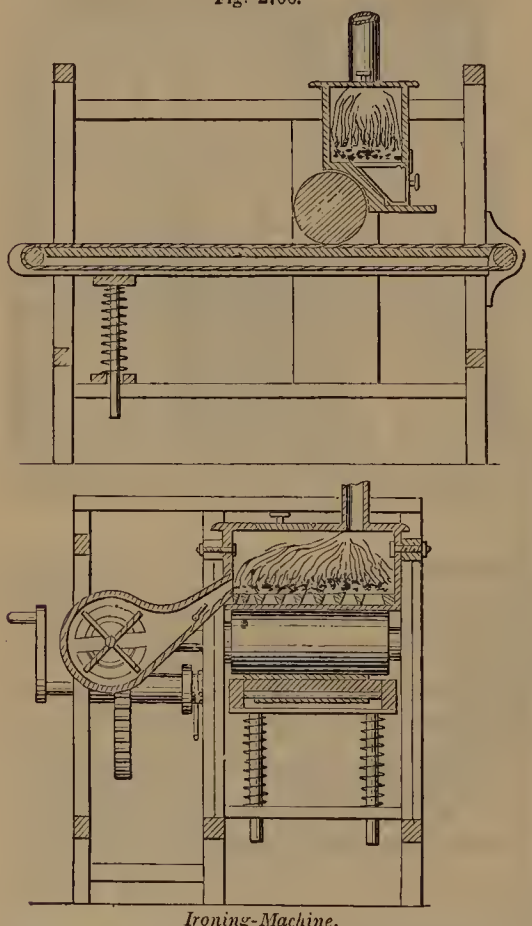
Hat-Lathe.

in which the clothes are carried on the endless belt under the heated roller. The table is depressible to allow the passage of heavy articles. The roller cover is the bottom of the fire-chamber, and the fire is urged by air from a blower driven by the crank which carries the endless apron.

I'ron-liq'uor. (*Dyeing.*) A solution of acetate of iron, used as a mordant by calico-printers.

I'ron-man. (*Cotton-manufacture.*) A name applied to the self-acting mule invented in 1825 by Roberts, of Manchester, England. The working of

Fig. 2706.



Ironing-Machine.

the ordinary mule was confided to the most skillful operatives. The machine by which their services were dispensed with was regarded as a triumph of ingenuity, and was thus named. See MULE.

I'ron-pa'per. A name given to extremely thin sheet-iron, which has been rolled thinner than the finest tissue-paper. In the American Department of the British Exhibition of 1851 very thin specimens were shown, and from this period a lively competition ensued as to who would show the finest and thinnest specimens. The results are mentioned under SHEET-IRON (which see).

I'ron-pipe. Welded iron tubes are made of skelps bent to a circular form, heated to a welding heat in an appropriate furnace, and then drawn on a draw-bench through a pair of jaws with bell mouths. The mouths are opened to receive the end of the skelp, and then closed. The tube is drawn without a mandrel. The sizes are from —

6 inches internal diameter, $\frac{1}{8}$ to $\frac{3}{8}$ inch thick.

$\frac{1}{4}$ inch internal diameter, $\frac{1}{10}$ inch bore.

For *cast-iron water-pipes* the working tension may be $\frac{1}{6}$ of the bursting tension, say, —

Bursting tension . . .	16,500 pounds.
Proof tension . . .	5,500 "
Working tension . . .	2,750 "

The working tension of *cast-iron steam-pipes* should be $\frac{1}{8}$ only of the ultimate tension.

I'ron-rust Ce-ment'. A cement for stopping joints or cracks in iron-work. It consists of iron borings or filings, 112; sal-ammoniac, 1; sulphur, 1; whitening, 4. Mix with water and use. It forms a dense rust. See CEMENT, page 508.

I'ron-sand. 1. (*Pyrotechnics.*) Steel filings, used in pyrotechny for brilliant fire, etc.

2. A variety of octohedral iron ore in grains.

I'ron, Sheet. See SHEET-IRON.

I'ron-stone Chi'na. One of the contributions of Wedgwood to the ceramic art.

The materials of the Staffordshire ware are calcined flints and clay. The flints are burned in kilns, and then, while hot, quenched in water, by which they are cracked through their whole substance. After being quenched they are ground, with water, in mills resembling the arrastra. The mill is a hollow cylinder of wooden staves bound with hoops, and having a bottom of blocks of chert; the mill-shaft is perpendicular and has two horizontal arms, between which are laid loose blocks of chert, which are moved round on the bed-stone as the arms revolve, and thus grind the flint with water to the consistence of cream.

The clay, from Dorsetshire and Devonshire, is mixed with water, and in this state, as well as the flint, is passed through fine sieves to separate the grosser particles. The flint and clay are now mixed by measure, and the mud or cream is passed again through a sieve, in order to render the mixture more complete.

In this state it is called *slip*, is then evaporated to a proper consistence in long brick troughs, and tempered in the pug-mill. Cups, pots, basins, and other round articles are turned rough on the horizontal potter's-wheel, and when half dried are again turned in a lathe. They are then fully dried in a stove, and the remaining roughnesses are afterwards removed by friction with coarse paper. Articles that are not round, and the round ones that have embossed designs on their surface, are made of thin sheets of clay rolled out like dough, and then pressed into molds of plaster of paris; the molds, being previously dried, absorb the superficial moisture of the clay, and thus allow it to part from them without injury. The two or three separate pieces composing the article are then united by means of slip. Spouts and handles of jugs and teapots are united with the body of the vessel in the same way. Small handles, beadings, moldings, etc., are formed by means of an iron cylinder having its bottom perforated, so as to mold the clay, as it passes through, into the required figure. A piston descends slowly

in the cylinder, and drives the clay out through the perforation ; it is then cut off in lengths. To form a plate, a lump of clay is beaten or rolled into a flat cake, which is then laid on a mold turned to the shape of the upper surface of the plate. A rotary motion is given to the mold, and an earthenware tool representing a section of the bottom of the plate is pressed on it. Cups, saucers, and basins, when rough turned, are dried on the block to keep them from warping. The ware, being thoroughly dried, is packed into saggars and burned in the kiln to biscuit. Patterns for flat or nearly flat surfaces are put on by printing the pattern from a copperplate with an ink composed of oxide of cobalt, oxide of iron, or other coloring matter, mixed with oil. The impression is taken on tissue-paper, and is applied without drying to the surface of the biscuit, and slightly rubbed to make the print adhere ; the biscuit is then soaked in water till the paper may be stripped off, leaving the print or pattern behind. The ware is then dipped in the glaze, which is a mixture of flint slip and white-lead, and the bibulous quality of the biscuit causes a sufficient quantity to adhere ; the piece is then dried and again passed into the furnace, which brings out the colors of the pattern, and at the same time vitrifies the glaze.

The finest patterns for curved surfaces are applied after the glazing has been completed, by taking the impressions from the copperplate on a flexible strap covered with a strong gelatinous mixture of glue and treacle. This strap is then pressed on the ware, and gives the impression in glue ; the coloring powder is then dusted over it, and a sufficient portion adheres to the damp parts to give the pattern, after having been again in the kiln. The more elaborate patterns on earthenware, and all those on porcelain, are finished by penciling in.

Iron Ves'sel. The first iron boat was built in 1787, by J. Wilkinson, of Bradley Forge, England. It was 70 feet long, 6 feet 8½ inches beam. The plates were $\frac{5}{16}$ inch, secured by rivets. The stem and stern-post were of wood, the beams of elm planks. Her weight was 8 tons, capacity 32 tons ; she drew 8 to 9 inches of water when light, and plied on the Birmingham Canal.

An iron pleasure-boat was launched on the Mersey in 1815 by T. Jevons of Liverpool. It was scuttled by jealous shipbuilders, and an iron *life-boat* launched by the same person in 1817 experienced the same fate.

The first iron steam-vessel launched and put to sea was projected and built for A. Manby of Staffordshire, for the river Seine, in 1821. She took in a cargo of linseed-oil and iron castings, and was navigated direct from London to Havre, and from that port proceeded to Paris, where she discharged her cargo. She navigated the Seine for many years, and may yet.

The iron steamboat "Alburkah," for the Lander Expedition up the Niger, was built in 1831. She was 70 feet long, 13 feet beam, and 6½ feet deep. When launched she drew 9 inches of water ; when equipped she drew 40 inches. She was navigated to the scene of her exploits, twice ascended the river, and her ribs upon the strand of Clarence Cove were visible but a few years since, and may yet remain. Her engines were 16 horse-power. Her weight, without engine, 33,600 pounds.

The "Garry Owen" was the first iron vessel with water-tight bulkheads ; suggested by C. W. Williams. See BULKHEAD.

Iron vessels for America, Ireland, France, India, and China were built in Scotland and on the Mersey, 1833–39.

The iron steam-vessels "Nemesis" and "Phlegethon" were used in the villainous Opium War of 1842. They were not the last vessels built on the Clyde for piratical expeditions.

The "Ironsides" was the first iron sailing vessel of any magnitude employed for sea voyages.

The "Great Britain," built at Liverpool, was the boldest effort in iron shipbuilding in her time, but was eclipsed by the "Leviathan," afterwards renamed the "Great Eastern," which was built from the designs of Brunel, by Russell & Co., at Millwall, on the Thames.

She was commenced in 1853, and was four years in building.

The proportions and capacity are as follows : —

Length between perpendicular	680	feet.
Length on upper deck	692	"
Breadth of the hull	83	"
Breadth, including paddle-boxes	118	"
Depth of the hull	60	"
Weight of iron in the hull	16,800,000	pounds.
Weight with engines, stores, and complement	56,000,000	"
Draft, loaded	30	feet.
Number of iron plates	10,000	
Number of rivets	3,000,000	
Passenger capacity, first class	800	
Second class	2,000	
Third class	1,200	
	4,000	
Crew and engineers	400	
Paddle-wheels, in diameter	56	feet.
Float-boards, in length	13	"
Screw-propeller, diameter	24	"
Screw-propeller, length of shaft	160	"

The design was to make the "Great Eastern" on the principle of a wrought-iron girder. For this purpose, the bottom, sides, and deck are cellular, and each shell water-tight. The distance between the shells is 34 inches, and is traversed by 35 ribs or webs running longitudinally from stem to stern. Similar webs traverse the cellular deck.

An elaborate system of transverse and longitudinal bulkheads divides the vessel into numerous compartments, so arranged as to form the required spaces for engines, boilers, coals, cargo, and passengers. Of these are 10 or 12 transverse, water-tight bulkheads, which have no openings below the lower deck.

The means of propulsion are paddles, screw, and sails ; six masts carrying 6,500 yards of canvas.

The details of the donkey and pumping engines, gas and telegraph apparatus, the fleet of boats, and the two steam-tenders, 90 feet long, hanging from davits abaft the paddle-boxes, are highly interesting, and may be found in the journals of the day and in works specially devoted to marine and steam engineering.

I'ron-wheel. See CARRIAGE-WHEEL ; CAR-WHEEL.

I'ron-work Paint. Graphite and hot coal-tar.

Solution of silicate of soda (20° Baume), 2 parts ; zinc oxide, 1 part.

Asphaltum and resin, equal parts, dissolved in spirits of turpentine.

For machinery : caoutchouc, 2 pounds ; resin, 4 pounds ; shellac, 2 pounds ; 5 gallons of benzine.

For wrought-iron structures : scrub with wire brushes, fill crevices with a putty of litharge, linseed-oil, varnish, and white lead ; repeat the brushing ; apply a paint of white-lead, 300 pounds ; crude linseed-oil, 10 gallons ; boiled linseed-oil, 2 gallons ; turpentine, 1¼ gallons. Blow white sand on to a second coat of the same.

Rub the work with heavy petroleum.

Galvanizing-paint: zinc powder and oil varnish.

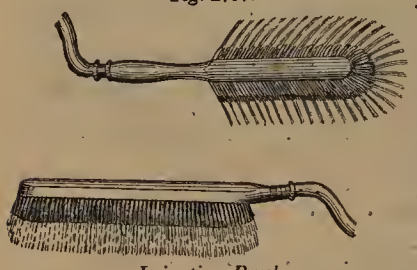
Rub the red-hot iron with wax, tallow, pitch, or coal-tar. See also VARNISH.

For bright-work; during transportation and at sea: tallow, with a little white-lead to give it consistence. It is rubbed off when the machine is set up, or the vessel is nearing port.

Ir-reg'u-lar Wheel. Several varieties of gears may be termed irregular; but the variability of each is in regular terms, if the motion of the wheel be continuous; the parts passing through recurrent series of consecutive changes. See ANGULAR WHEEL; CAM GEAR-WHEEL; ECCENTRIC WHEEL; ELLIPTICAL WHEEL; INTERMITTENT WHEEL; MUTILATED WHEEL; SCROLL-WHEEL; SECTOR-WHEEL; SPIRAL WHEEL; VARIABLE WHEEL.

Ir'ri-gat-ing-brush. One having concealed holes through which jets or spray of water passes, in the line of the bristles. An elastic tube leads the water to the brush. It is especially used for cleaning carriages.

Fig. 2707.



Irrigating-Brush.

Ir'ri-ta'tion-in'strument. An acicular instrument used to penetrate the skin as a local irritant. Sometimes used to introduce a vesicatory liquid beneath the epidermis. See ACUPUNCTURATOR; HYPODERMIC SYRINGE.

I'sin-glass. A fine kind of glue or hardened gelatinous composition, composed of dissolved membraneous animal tissues.

The genuine is made in Russia from the sounds and air-bladders of sturgeon, but other kinds are made either of clean scraps of hide, etc., or the purified jelly derived from the digestion of skins, hoofs, horns, etc. In the latter case, it is glue purified by the discharge of fetid smells and putrid flavors.

I-sod'o-mon. A style of masonry in which the face is formed of squared blocks, the courses of equal hights, and the filling of smaller blocks in courses.

The *pseudisodomon* had courses of varying hight. See MASONRY.

I-so-met'ri-cal Pro-jec'tion. A mode of drawing machines or buildings, in which the plan and elevations are shown in one view. Three planes are projected at an equal angle upon a single plane.

I-tal'ian I'ron. A laundress's smoothing-iron for fluting and smoothing frills.

I-tal'ian Roof. A hip-roof.

I-tal'ic. Inclined type of a peculiar form, as, —

Italic type is said to have been copied from the handwriting of Petrarch, by the famous printer Aldus Manutius. He obtained a patent for the use of this character in type from Pope Leo X., surnamed The Great.

I'vo-ride. An artificial ivory. A vulcanite whitened by abundant quantity of some white material. See IVORY, ARTIFICIAL.

I'vo-ry. Specifically, the material constituting the tusk of the elephant.

In a more general sense the term includes the tusks of the walrus, narwhal, and even the teeth of some other cetacea.

The African ivory is preferred to the Asiatic; it has a greater proportion of animal matter, and is less liable to discoloration.

	Animal matter.	Earthy matter.
African ivory . . .	51	50
Asiatic ivory . . .	38	50

The consumption of elephants' tusks in Sheffield, England, is about 45,000 *per annum;* and, allowing for the occasional finding of shed tusks, and those of elephants found dead, it is estimated that 20,000 are slaughtered yearly to supply this *city of cutlers.*

Ivory is rendered flexible by steeping in a solution of hydrochloric acid. This extracts the phosphate of lime and gives flexibility to the ivory, without impairing its form. Tubes and probes of this material have been made, and the partial hardness which occurs on drying may be removed by surrounding the piece with wet linen, or placing pellets of wet sponge in the cavities of the instrument.

Or immerse ivory in a solution of pure phosphoric acid, s. g. 1.130, until the opacity is removed; wash and partially dry. Will become hard when perfectly dry, but again becomes flexible when placed in hot water.

Another mode of softening ivory is to soak it for three or four days in a mixture of 3 ounces of spirit of niter and 15 ounces of spring-water, when it will be soft enough to obey the fingers. To color it in this state, dissolve the proper pigment in spirit of wine, then immerse the ivory and leave until sufficiently tinged, then give it the proper form. To harden it, wrap in a sheet of white paper and cover with dry, decrepitated common salt, and leave for twenty-four hours. To whiten ivory that has turned brown, slack some lime in water, decant, and boil your ivory in this till white. It is also bleached by sulphurous acid, by chloride of lime, or by soaking in water and exposure to the sun.

Ivory brought from Nineveh in a fragile and crumbling state was restored by Professor Owen to a rigid condition by boiling it in a solution of gelatine. The animal matter had decayed out of it, leaving the phosphate of lime ready to fall to pieces.

A veneer of ivory was exhibited at the World's Fair in London, 1851, 41 feet long and 14 inches wide. It was sawn from a block in a continuous ribbon, the block rotating and its axis gradually approaching the plane of motion of the saw.

Russia affords a large supply of tusks from the remains of an extinct variety of elephant which once roamed the now inhospitable shores of the Siberian rivers. These bones, though not essentially changed in condition, are called fossil ivory, from the circumstances of their deposit and discovery.

The fruit of *Phytelephas macrocarpa*, a species of Peruvian palm, is the vegetable ivory of commerce.

Ivory has always been considered a luxurious article in countries where it is not indigenous. The Assyrians carried on a great traffic in ivory. In an Assyrian obelisk in the British Museum, the captives or tribute-bearers are represented as carrying elephants' tusks. The Egyptian monuments show the tusks, apes, and peacocks carried to Sesostris; the same articles were also brought to Solomon by the navy of Tarshish some hundreds of years later. Diodorus Siculus states that the Ethiopians brought to Sesostris "ebony and gold, and the teeth of elephants." Pliny states that ivory was so plentiful on the borders of Ethiopia that it was used for fences, door-posts, and cattle-stalls.

In regard to its ancient uses, it seems to have been essentially a regal luxury. "All manner of vessels of ivory" are enumerated as among the furnishing of opulent Babylon. Hiram fashioned the great ivory throne of Solomon, and overlaid it with pure gold. Ivory was freely used in the chairs and couches of

Egypt, as the paintings in the tombs yet testify. Ahab's ivory house, 900 B. C., and the palace of Menelaus, described by Homer, were probably paneled with ivory, or the walls and pillars inlaid therewith. Ezekiel records that ivory was used to ornament the Phœnician galleys.

Beds inlaid or veneered with ivory were used by those who, as Amos says, "are at ease in Zion," "that lie upon beds of ivory and stretch themselves upon their couches."

Two hunting inscriptions, one of which principally records the elephant hunts of Ptolemy Philadelphus, were discovered and copied by Lepsius from the colossi of Aboo Simbel. Since ancient times elephants have withdrawn more to the south in Eastern Africa also. According to the testimony of Polybius, when African and Indian elephants encountered each other on fields of battle, the sight, the smell, and the cries of the larger and stronger Indian elephants drove the African ones to flight. The latter were never employed as war elephants in such large numbers as were used in Asiatic expeditions, where Khandragupta had assembled 9,000, the powerful king of the Prasii 6,000, and Akbar as many.

The Numidian Metellus had 142 elephants killed in the circus. In the games given by Pompey, 600 lions and 406 panthers were shown. Augustus sacrificed 3,500 wild beasts in the festivities which he gave to the people; and a tender husband laments that he could not celebrate the day of his wife's death by a sanguinary gladiatorial fight at Verona, because contrary winds detained in port the panthers which had been bought in Africa.

To come down to a later date, ivory chairs and furniture were among the spoils of Seringapatam when Tippoo yielded up the ghost, and the government of Mysore.

The "Elephant's Tower" at Futtehpoor Sikra, a favorite residence of Akbar, the most illustrious Asiatic ruler of modern times (1556–1605), is ninety feet high, and is studded with elephants' tusks from top to bottom. It is conjectured to have been erected over the remains of a favorite elephant. This Akbar (very great), properly JELAL-ED-DIN MOHAMMED, was truly royal, and "kept house" on a very extended scale. Bayard Taylor gives a good account of Futtehpoor, a red sandstone city, deserted but not destroyed. Akbar had a fancy for chess-playing within a checkered court-yard of his palace, with beardless eunuchs and troops of girls, who strutted and trotted from point to point as the dice were thrown and the moves called. See CHESS.

I'vo-ry, Ar-ti-fi'ci-al. A compound of caoutchouc, sulphur, and some white ingredients, such as gypsum, sulphate of baryta, oxide of zinc, or pipeclay.

Pinson's: immerse a sheet of gelatine in alumina, dissolved in acetic acid. When fairly combined, take out, hang up to dry, and polish.

Welling's artificial ivory is composed of 10 ounces of white shellac, 4½ ounces acetate of lead, 8 ounces of ivory dust, and 5 ounces of camphor. The ingredients are reduced to powder, heated, and mixed, then pressed in heated molds into sheets or other desired forms. See PYROXYLINE.

Another: two pounds of pure india-rubber are dissolved in thirty-two pounds of chloroform, and the solution saturated with purified ammoniacal gas. The chloroform is then evaporated or distilled off at a temperature of 185° Fah. The residue is mixed with pulverized phosphate of lime or carbonate of zinc, pressed into molds and cooled. When the phosphate of lime is used, the resulting compound partakes in a great degree of the nature and composition of genuine ivory, for the phosphate replaces the lime, and the india-rubber takes the place of the gelatine.

Ivory dust mixed with albumen, rolled into sheets, dried, and polished.

Sulphate of baryta and albumen rolled into sheets.

Billiard-balls made of a mixture of paper pulp, sulphate of baryta, and gelatine, are said to be equal to those made of ivory.

Plaster of paris saturated with melted spermaceti.

The following United States patents bear upon this subject; the figures are day, month, year: —

Welling	4, 8, 1857.	Seeley	23, 6, 1868.
Held	4, 8, 1857.	Welling	5, 5, 1868.
Hackert	31, 5, 1864.	Gradenwitz	25, 5, 1869.
Dupper	1865.	Hyatt and Blake	4, 5, 1869.
Wheeler	14, 11, 1865	Welling	20, 4, 1869.
Wurtz	1, 1, 1867.	Welling	27, 4, 1869.
Hackert	19, 2, 1867.	Welling	27, 4, 1869.
Starr	3, 3, 1868.	Hyatt	6, 4, 1869.
Starr and Welling	9, 6, 1868.	Hyatt	6, 4, 1869.
Hyatt	14, 4, 1868.	Hyatt	15, 6, 1869.
Gardner	7, 1, 1868.	Welling	17, 1, 1870.

I'vo-ry-black. A species of bone-black made by the calcination of ivory scraps, turnings, and sawdust. It is used as a pigment in the manufacture of paints and printers' ink.

I'vo-ry-pa'per. A superior article of pasteboard, with a finely prepared polished surface, used by artists.

Ainslie's process for making ivory-paper is as follows: —

Digest four ounces of clean parchment cuttings in water for four hours, and strain off the jelly. Digest again for a farther quantity. Keep these apart as Nos. 1 and 2. Saturate with No. 2 two sheets of drawing-paper, 15 × 17 inches, lay them together, and strain them over a smooth slate, pasting them on the back. Allow them to dry gradually. Wet three more sheets and add them to the former, one at a time. When dry, smooth with sand-paper; wet and add a perfectly clean sheet. Dry it and smooth with fine glass-paper. Heat one half-pint of size of No. 1, and stir into it three tablespoonfuls of plaster of paris; distribute it over the surface; dry; polish with glass-paper. Spread several coats of size No. 1 upon the surface, polishing each time with fine glass-paper. Plaster of paris, oxide of zinc, and carbonate of baryta give different tints.

I'vo-ry-saw. A thin saw stretched in a steel frame for sawing ivory from the solid. It has a blade $\frac{1}{40}$ inch thick, 1½ inch wide, and 15 to 30 inches long. The teeth, 5 or 6 to the inch. A frame-saw with a blade made of a fine watch-spring is suitable for the purpose.

I'vo-ry-tab'let. Small leaves of ivory, arranged in pocket-book form, for receiving memoranda.

Artificial ivory tablets for photography are made by mingling finely pulverized sulphate of baryta or heavy spar with gelatine or albumen, compressing the product into sheets, and drying it.

The laws of the twelve tables of Rome were originally written on oak, then transcribed on ivory tablets, and hung up *pro rostris;* after approval by the people, they were engraved on bronze. The opulent Romans used their slips of ivory, called *libri eborici* or *libri elephantini;* and Ulpian states it was common to write on such with black ink.

I'vo-ry-type. (*Photography.*) A kind of picture in which two finished photographs are taken, one light in color, made translucent by varnish, tinted on the back, and placed over a stronger picture, so as to give the effect of a photograph in natural colors. Also known as *Hellenotype.*

I'vo-ry, Veg'e-ta-ble. The nut of the *Phytelephas macrocarpa.*

J.

Jab. (*Nautical.*) To catch fish by prodding; said of fishing with a *gaff*.

Jabb. A peculiar fishing-net for catching the fry of fish.

Jack. A handy tool. A name applied to a convenient implement which answers in the place of another hand or of an assistant. It is frequently compounded with other words, the associated word expressing either its purpose, structure, or relation.

As a simple word it has meanings: —

1. A lifting instrument. See JACK-SCREW; WAGON-JACK; WHEEL-JACK; CAR-JACK; FENCE-JACK; RAIL-JACK; HYDROSTATIC JACK, and others in the list below.

2. An instrument for turning a roasting joint of meat. A *bottle-jack*, or a *smoke-jack*.

3. (*Knitting.*) The pivoted bar or lever in a knitting-machine, from whose end is suspended the sinker which forms the loop. A *beater*.

4. (*Spinning.*) A coarse bobbin and fly-frame, operating on the sliver from the carding-machine and passing the product to the fine roving-machine, or fitting it therefor.

5. (*Weaving.*) The *heck-box*; a grated frame for conducting the threads from the *bank* to the *warping-mill*.

6. (*Mining.*) A wooden wedge used in mining for assisting in the cleavage of strata. A *gad*.

7. A saw-horse or saw-buck. Two X-shaped frames united by a round or rundle.

8. A small flag. The *union* without the *fly*. See FLAG.

9. (*Metal-working.*) A form of *metal planing-machine* which has short, quick motions, and is used in shaping objects, planing seats for valves, faces for the same, etc.

10. (*Nautical.*) The cross-trees.

11. (*Music.*) Formerly the hammer or quill-carrier of a clavichord, virginal, harpsichord, or spinet, but now an intermediate piece which conveys to the hammer the motion imparted to the key.

The piano-movement jack, which imparts the motion of the key to the hammer, is the invention of Christofori of Florence, 1711. Rimbault's "Pianoforte," London, 1860. See PIANO-FORTE.

As a compound word, see under the following heads: —

Boot-jack.
Bottle-jack.
Builder's jack.
Carriage-jack.
Chimney-jack.
Claw-jack.
Crick.
Fence-jack.
Hand-screw.
Hoisting-jack.
Hydraulic jack.
Hydraulic lifting-jack (see HYDRAULIC PRESSES AND LIFTERS).
Hydrostatic jack.
Jack-arch.
Jack-back.
Jack-block.
Jack-boots.
Jack cross-tree.
Jack-frame.
Jack-head pump.
Jack-in-a-basket.
Jack-in-a-box.
Jack-knife.
Jack-ladder.
Jack-pin.
Jack-plane.
Jack-rafter.
Jack-screw.
Jack-sinker.
Jack-staff.
Jack-stay.
Jack-timber.
Knitting-machine jack.
Lever-jack.
Lifting-jack.
Minute-jack.
Pegging-jack.
Piano-movement jack.
Post-jack.
Pulling-jack.
Pushing-jack.
Rack-and-pinion jack.
Rail-jack.
Railroad-jack.
Ratchet-jack.
Roasting-jack.
Rounding-jack.
Screw-jack.
Shackle-jack.
Shaft-coupling jack.
Ship-jack (see HYDRAULIC PRESSES AND LIFTERS).
Shoe-jack.
Smoke-jack.
Spinning-jack.
Swing-jack.
Telescopic jack.
Thill-jack.
Traversing jack (see HYDRAULIC PRESSES AND LIFTERS).
Tripod-jack.
Truck-jack.
Wagon-jack.
Warping-jack.
Wheel-jack (see HYDRAULIC PRESSES AND LIFTERS).
Windlass-jack.
Window-jack.

Jack-arch. An arch of the thickness of one brick.

Jack-back. 1. A vessel below the brewery-copper which receives the infusion of malt and hops therefrom, and which has a perforated bottom to strain off the hops.

2. A tank or cistern which receives the cooled wort in a vinegar-factory.

Jack-block. (*Nautical.*) A block used in sending the top-gallant mast up and down.

Jack-boots. 1. Large, overall boots, reaching up the thigh; worn by fishermen.

2. Large boots with a front-piece coming above the knee; worn by cavalry-men, and sometimes by huntsmen.

Jack Cross-tree. (*Nautical.*) An iron cross-tree at the head of a top-gallant mast.

Jack'et. An enveloping or outer case of clothing, steam, water, or other substance.

1. A *steam-jacket* is a body of steam between an inner and outer cylinder or casing; its usual purpose is to warm or maintain the warmth of the contents of the inner cylinder. It was invented by Watt.

The steam space around an evaporating-pan to heat the contents.

Other jackets are of wood or other non-conducting material. Cylinders of steam-engines are sometimes covered with felt and an ornamental wooden casing to prevent radiation of heat. Steam-boilers, for the same purpose, are jacketed with felt on the upper part. *Cleading, deading, lagging.*

2. (*Nautical.*) *a.* A double or outer coat.

b. A casing for a steam-chimney where it passes through a deck.

3. A swimming garment with cork lining. A *cork-jacket*.

Jack-frame. (*Cotton-manufacture.*) A device, formerly in greater favor, for giving a twist to the roving as it was delivered by the drawing rollers.

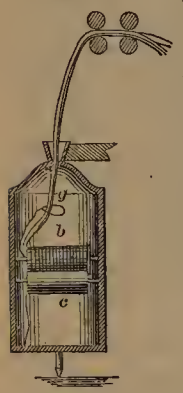
In order to give a certain degree of cohesion to the sliver, the can into which it was received from the drawing rollers received a rapid rotation, imparted by the table on which it stood. See DOUBLING; ROVING.

Following this process was that of winding it upon bobbins, so as to be fed from thence to the spinning-frame.

The *jack-frame*, or *jack in the box*, was devised to twist and wind the sliver and form it into a roving on a bobbin *in the can*.

The twist is given to the sliver by the revolution of the can on its vertical axis; but instead of being coiled up within the can as usual (see DOUBLING), the roving was wound upon a bobbin *b* lying upon a carrier cylinder *c* made to revolve by wheel-work (not shown) at such a rate that its surface velocity corresponded to that of the delivering drawing roller. A guide-wire *g* moved backward and forward in front of the bobbin distributes the roving equally thereon. The *jack-frame* was superseded by the BOBBIN and FLY-FRAME (which see). The mode of rotating the bobbin survives in Mason's speeder.

Fig. 2708.



Jack-Frame.

Jack-head Pump. A form of lift-pumps for mines and deep borings, in which the delivery-pipe is secured to the cylinder by a goose-neek. See PLUNGER-PUMP.

Jack-in-a-bas'ket. (*Nautical.*) A basket on a pole marking a shoal. A beacon.

Jack-in-a-box. 1. A name conferred upon the *jack-frame*, a device for giving a twist to the drawn *sliver* and winding the same on a bobbin as it was received in the *roving* can. See JACK-FRAME.

2. *a.* A large, wooden, solid screw turning in a nut in a bridge-piece and rotated by means of a lever. It is a clumsy form of screw-press, used for various purposes.

b. A screw-jack for lifting and for stowing cargo.

Jack'knife. A horn-handled clasp-knife with a laniard, worn by seamen.

Jack-lad'der. (*Nautical.*) One with wooden steps and side ropes.

Jack-pin. (*Nautical.*) A belaying-pin in the fife-rail or elsewhere.

Jack-plane. (*Carpentry.*) The first and coarsest of the joiner's bench-planes; the others being the *trying*, *panel*, and *smooth* planes. It is about 18 inches long.

Jack-raft'er. (*Carpentry.*) One of the short rafters used in a *hip-roof*.

Jack-screw. A lifting implement which acts by the rotation of a screw in a threaded socket. In *A* the screw is double, the portion *a* turning in *b*, and the latter in the collar of the base *c*. The spanner *d* rotates the nut *e* and with it the screw *b*, which climbs out of *c* and at the same time projects *a*.

B is a railway-jack, moved by a lever (which is shown broken off), and acting by pawl and ratchet, either throughout a circle or by reciprocation where the position is confined.

C is a traversing-jack which moves the load along by a secondary screw *f* so that the standard *g* slips on the ways *h*.

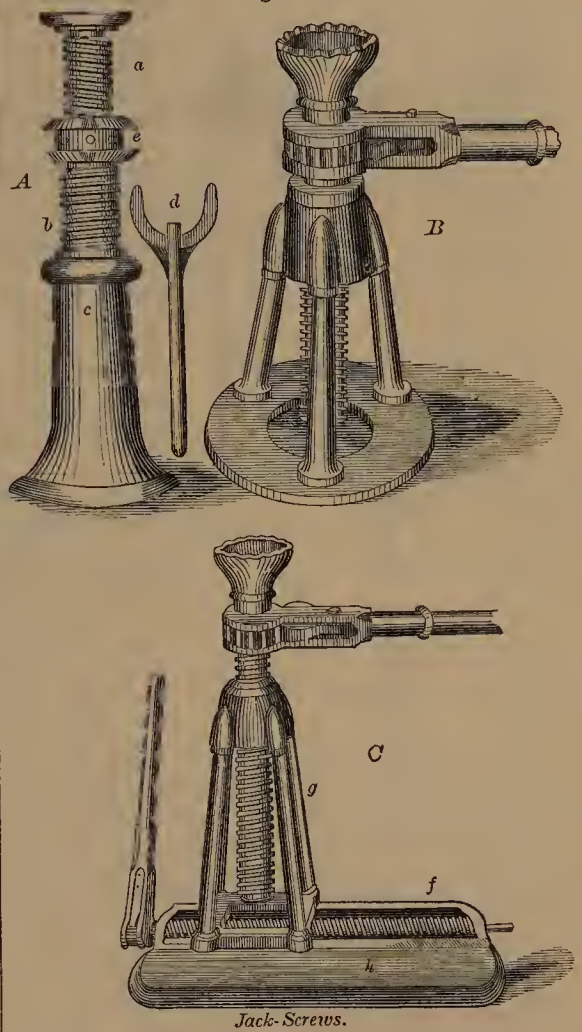
In another form the screw is rotated by bevel-wheel and pinion.

Jack-sink'er. (*Knitting-machine.*) A thin iron plate suspended from the end of the *jack*, and acting to depress the loop of thread between two needles. The jack-sinkers, alternate with *lead-sinkers*, the former being movable separately, but the latter are attached to a *sinker-bar*, and move together. See KNITTING-MACHINE.

Jack-staff. (*Nautical.*) A flag-staff on the bowsprit-cap for flying the jack.

Jack-stay. (*Nautical.*) A rib or plate with holes, or a rod running through eye-bolts, passing along the upper side of a yard, and to which the sail is bent.

Fig. 2709.



Jack-Screws.

Jack-tim'ber. (*Carpentry.*) A timber in a building which is shorter than the other timbers, being intercepted by another piece; as, —

A *studding* in a partition, which is intercepted by a brace or a window or door frame.

A *rafter* in a hip-roof, which meets the hip and is shorter than those which run to a full length and meet at the comb or ridge.

A *rib* in vaulting or groining, shorter than the main rib.

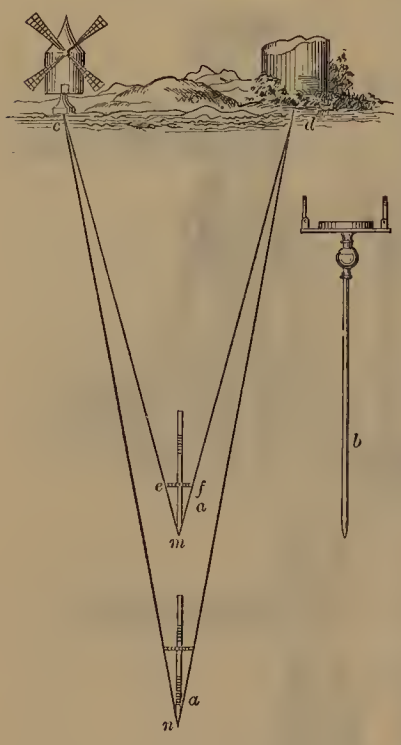
Ja'cob's Lad'der. (*Nautical.*) A rope ladder with wooden rounds.

Ja'cob's Staff. 1. An instrument for taking altitudes, having a brass circle divided into four equal parts by two diametric lines. At each extremity is a perpendicular riglet over the lines, with a hole below each slit for discovering objects. The cross is mounted on a staff. A *cross-staff*.

2. (*Surveying.*) An instrument (*a*, Fig. 2710) used to measure distances and heights. It has a square rod, with a cross or cursor, which has a set screw to keep it in position on the rod when required. The rod is three or four feet in length, and divided into four or five equal parts. The cursor has a square socket and slips on the staff; its length is equal to one of the divisions of the staff. The instrument is mounted on a tripod when in use, the cursor being in the plane of the horizon when measuring distances, and vertical thereto when measuring hights.

The cursor is adjusted on the rod to the second

Fig. 2710



Jacob's Staff.

division, and the observation taken from such a position that the direction of the staff bisects the angle subtended by a line drawn between the two objects. Retire or advance with the instrument until from the station *m* the visual line from *m* passing to *e d* will touch the ends *e f* of the cursor. Place a picket at *m*. Slip the cursor on to the third division of the staff and retire till from a new station *n* the visual rays from thence will reach the same objects, *c d* touching *c f* as before. Drive a picket. The distance between the pickets is equal to the distance between the objects. This is but one illustration of its application. See Cresy's "Encyclopedia Civil Engineering," edition 1865, pp. 832–835.

3. A straight rod *b* shod with iron, and with a socket joint and pintle at the summit for supporting a surveyor's *circumferentor*.

Jac-o-net'. (*Fabric.*) A fine, close, white cotton goods, like cambric.

Jac'quard Loom. A loom for weaving figured goods. A chain of perforated cards is made to pass over a drum, and the strings by which the threads of the warp are raised pass over an edge with a wire or leaden weight of small diameter suspended from each. These weights, at each stroke of the loom, are presented to each successive card, and some of them are intercepted by the card while others pass though the holes therein, the latter thus determining which threads of the warp shall be raised. In this way the figure on the card determines the nature of the figure on the fabric.

Jacquard, the inventor, was a straw-hat manufacturer at Lyons. His attention was first directed toward mechanical inventions by a reward being offered for the production of a machine for making nets. He produced the machine, but did not claim the reward. The attention of Napoleon was called to his inventive genius, and he was sent for to ascertain if he could not improve on a loom belonging to the government. This was designed for weaving shawl patterns in imitation of cashmere, and its setting up and arrangement were very troublesome and expensive.

The great war minister Carnot is reported to have said to Jacquard, "Are you the man who can do what the Almighty cannot: tie a knot on a stretched string?" Jacquard, improving on the model of Vaucanson, produced the apparatus which bears his name, and was rewarded with a pension of 1,000 francs. This was afterwards increased to 6,000. He was also awarded a bronze medal at the French Exposition in 1801.

On returning to Lyons, he met with great opposition from the weavers there, who endeavored to forcibly suppress the invention. The "Conseil de Prudhommes," a board of master workmen in the various branches of trade, who are appointed to look after the manufacturing interests, adjust wages, and settle disputes between masters and workmen, ordered his machine to be broken up in the public place, and, according to Jacquard's own expression, "the iron sold for iron, the wood for wood, and he, the inventor, was delivered over to universal ignominy." The value of the invention was, however, soon appreciated elsewhere, and was finally recognized by the Lyonese themselves, to whom it has since proved of inestimable value.

Jag. A barb or dovetail which resists retraction.

Jag-bolt. One with a barbed shank.

Jag'ger. 1. (*Domestic.*) A small wheel mounted in a handle and used for crimping or ornamenting edges of pies, cakes, etc., or cutting them into ornamental shapes. A *jagging-iron*.

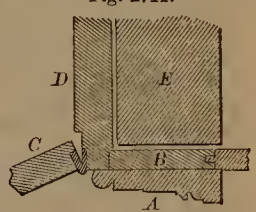
2. A toothed chisel.

Jag'ging-board. (*Metallurgy.*) An inclined board in a *buddle* or *frame* on which *slimes* of ore are deposited to be gradually washed by a current of water to the inclined bed where the slimes are sorted according to gravity. See Buddle; Framing.

Jal-ou-sie'. A *louvre* or *Venetian* shutter.

Jamb. 1. (*Architecture.*) The upright sides of an aperture, as a doorway, window, or fireplace, and supporting the lintel, entablature, or mantel.

Fig. 2711.



Jamb and Fittings.

The *jamb-linings* are the casing, and have a rabbet for the door to shut into.

Jamb-posts are framed into an aperture, and upon them the *linings* are attached.

Jamb-stones are employed in building sides of an aperture.

A, architrave.
B, plowed ground.
C, door.
D, rabbeted joint.
E, quarter.

2. (*Mining.*) A pillar of ore in a mine.

Jamb-lin'ing. (*Carpentry.*) The vertical boarding on the sides of a doorway.

Jamb-post. (*Carpentry.*) One of the uprights on the sides of a doorway or window.

Jamb-stone. (*Architecture.*) One of the stone pillars on the sides of a doorway or of a window.

Jam'da-ri. (*Fabric.*) A Dacca muslin woven with figures of flowers and other ornaments.

Jam-nut. An auxiliary nut screwed down upon another one to hold it. A *check-nut*, *lock-nut*, or *pinching-nut*. See Nut-lock.

Jam-weld. (*Forging.*) A weld in which the heated ends or edges of the parts are square butted against each other and welded.

Jank'er. (*Scotch.*) A long pole on two wheels, used in transporting logs.

Jan'tu. A water-raising device of great antiquity used in Bengal for land irrigation. It is a trough counterweighted by an extended arm and balanced across a bar. As the trough end descends it dips water, and, as it rises, the water runs towards the axis of vibration and escapes at a lateral orifice into a trough, which conducts it to the field. See Gutter for a common device on this principle, excepting the counterweights. See also Bail-scoop.

Ja'nus-cloth. A fabric having each side dressed,

and different colors on the respective sides. Such fabric is used for reversible garments.

Ja-pan'. 1. A hard, black varnish, obtained from the *Stagmaria verniciflua* of the East Indies.

2. An asphaltum varnish. See VARNISH.

Ja-pan'-earth. (*Tanning.*) Terra japonica, catechu, cutch. An astringent matter obtained from the *Areca catechu* and *Acacia catechu;* used in tanning.

Jap-a-nese' Silk. (*Fabric.*) A dress goods having a linen chain and silken weft.

Ja-pan'-ink. A writing-ink which has a dark, glossy color when dry. See INK.

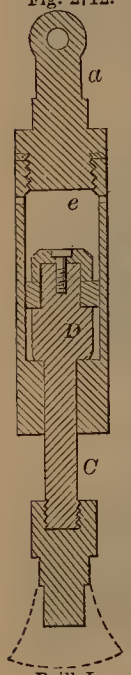
Ja-panned' Leath'er. Leather treated with several coats of Japan varnish and dried in a stove.

Ja-pan'ning. The art of coating wood, metal, or paper, with a thick coat of hard, brilliant, varnish. The art originated in Japan. *Japanning* involves the *baking* of the varnished article.

The Japanese employ a lacquer obtained from a tree by making incisions in the trunk and collecting the juice; this is at first like cream, but becomes black by exposure to the air. Their process is said to be as follows: After the juice has assumed a deep black color, finely pulverized charcoal is added to it. The lacquer is applied to an article in several successive coats, each being dried in the sun before the next is put on. It soon becomes extremely hard, and is polished with a smooth stone and water until it becomes as smooth as glass. On this surface ornaments and figures are traced with a brush dipped in a varnish of boiled oil and turpentine. Before this is quite dry, gold or silver leaf is laid on, and the whole afterward receives a finishing coat of varnish.

With us the work is first covered with a ground composed of anime (*Hymenæa courbaril*) varnish mixed with a pigment of the desired color; this is dried in a stove, after which three or four coats of varnish are applied. The varnishes employed are copal, anime, mastic, or seed lac. The latter gives the hardest surface, but is too dark for the more delicate grounds, and is therefore usually mixed with some other kind of varnish. Articles such as wood or *papier-maché*, which are too coarse, soft, or rough to receive the japanning immediately on their surfaces, are first covered with a priming composed of chalk or whiting. This is allowed to dry, and is then rubbed smooth.

Fig. 2712.



Drill-Jar.

Engravings or drawings are transferred to japan work in the following way: The engraving is printed or the drawing made on fine paper, previously prepared with a coating of isinglass or gum-water. This, when dry, is applied face downward upon the japan ground, which is covered with a thin coat of copal varnish; the paper is then moistened on the back with warm water, which loosens it so that it can be removed, leaving the print on the work. Or a print may be made on an elastic composition of glue, etc., which may be applied immediately on the japanned surface.

Jar. 1. (*Well-boring.*) A device used in boring by impact of the chisel, which is alternately lifted and dropped. As the rope attached to the piece *a* is lifted, the chisel-stock *C* slips until arrested by the enlarged portion *D*. When the piece *a* is dropped, by the sudden slacking of the rope, the chisel falls, and the portion *c* comes on top of the chisel-stock *D* to give it an effective blow.

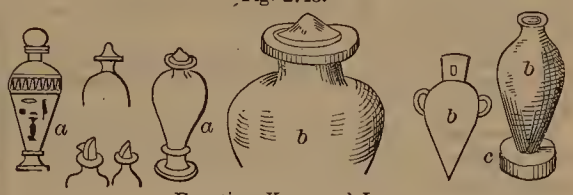
2. (*Domestic.*) A vessel of glass or earthenware for fruit, preserves, pickles, and various domestic uses.

The analogue of our modern fruit-jar is found in those of the ancient Egyptians, who seem to have been given to laying in great stores of provisions in this way. The paintings on the temples and tombs of Egypt show the storing of grain, wine, oil, poultry, and many other things, and the economy of their houses, pantries, and granaries shows that they made the most ample and profuse store of provisions. As an illustration, see Plate V. Vol. 2 of Wilkinson.

The jars of the accompanying cut have lids or stoppers, which are luted or rendered air-tight by liquid clay, pitch, gypsum, or mortar.

Some of the jars had flat bottoms *a*, and were set upon the cellar or store-room floor; and others, being

Fig. 2713.



Egyptian Vases and Jars.

pointed, were set in a stone ring, like the amphoræ *b b* and ring-base *c*. Late excavations on the site of Troy have exhumed ranks of enormous jars. See FRUIT-JAR.

Jas'per. 1. A silicious mineral of several varieties.

2. Marble of a greenish color, with small red spots. There is an antique jasper with small spots of black and white.

3. A kind of earthenware prepared from pounded spar.

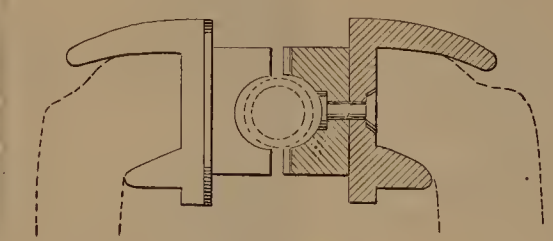
Jaunt'ing-car. An Irish vehicle having two seats, back to back, over the wheels, a well in the middle, and a seat for the driver in front.

Jave'lin. A hurling-spear, about 5½ feet long; it has a wooden shaft and an iron head. It is yet used in Europe in hunting the boar, and by many savage nations in ordinary hunting.

The *assegai* of the Caffre is a javelin of native iron.

Jaw. 1. (*Machinery.*) *a.* One of two opposing members capable of being moved towards and from

Fig. 2714.



Vise-Jaws for Round-Work.

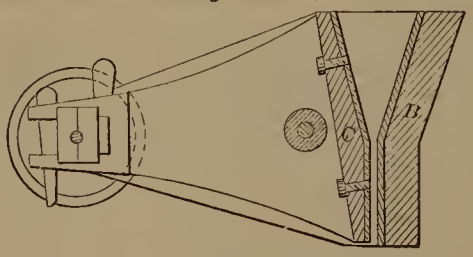
one another; as the *jaws*, *cheek*, *chaps*, *chops*, or *mouth* of a vise or wrench.

b. The cheeks of a stone or ore-crusher, one of which is moved relatively to the other, so as to break the material fed between them. In the example (Fig. 2715) *C* is the moving jaw, and *B* is a relatively stationary abutment. The movement of the jaw *E* is by an eccentric.

c. The opposed portions of a shearing-machine or punch, which, by moving past each other, cut the bar or sheet of metal placed between them.

2. (*Railway-cars.*) The guard-plates in which the axle-boxes of railway-cars play vertically as the springs yield and recoil. The *housings* or pedestals.

Fig. 2715.



Ore-Crusher.

3. (*Nautical.*) *a.* The forked end of a boom or gaff, which partially embraces the mast. The branches of the jaw are called *horns*, and are united by the *jaw-rope*.

b. The space in the shell of a tackle-block occupied by the sheave.

Jaw-lev'er. A veterinary instrument for opening the mouths of animals for the administration of medicine.

Jaw-tools. Tools having the capacity for grasping, as between jaws or fingers. See under the following heads : —

Animal-clutch.
Articulator.
Balance-vise.
Barrel-vise.
Bench-vise.
Bloom-hook.
Bolt-cutter.
Bottling-pliers.
Bullet-mold.
Burling-irons.
Burr-cutter.
Buttonhole-cutter.
Calipers.
Calking-vise.
Chimney-tongs.
Clamp.
Clincher.
Clothes-pin.
Clothes-tongs.
Clutch for hay-elevator.
Coal-tongs.
Compasses.
Costotome.
Crane's-bill.
Crimping-tool.
Crow's-bill.
Crucible-tongs.
Cutting-nippers.
Dividers.
Drawing-pliers.
Egg-tongs.
Elbow-tongs.
Entereotome.
Forceps.
Gas-fitter's tongs.
Glass-tongs.
Glazier's-vise.
Grapnalls.
Grapple.
Hand-vise.
Humbug.
Ice-tongs.
Inside-calipers.
Lasting-pinchers.
Lazy-tongs.
Monkey-wrench.
Nail-clincher.
Nippers.
Nut-cracker.
Pinchers.
Pinching-tongs.
Pipe-tongs.
Pipe-vise.
Pipe-wrench.
Pliers.
Pruning-shears.
Pucellas.
Punch-pliers.
Rivet-cutter.
Rotary shears.
Rounding-tool.
Saddler's-pinchers.
Saw-vise.
Scissors.
Shanks.
Shears.
Snipe.
Spring-vise.
Suspending-clutch.
Tongs.
Tube-cutter.
Tweezers.
Vise.
Wrench.

Jaw-wedge. A wedge to tighten the axle-box in the jaw or guard of a railway car-truck.

Jean. (*Fabric.*) *a.* A twilled, undressed cloth, having a cotton chain and woolen filling.

b. A twilled cotton goods, striped or white. *Satin jean* has a different twill, which gives it a smooth, glossy surface.

Jears. (*Nautical.*) A fourfold tackle by which a lower yard is *swayed* or *struck*. The upper block of this purchase usually hangs from the *trestle-trees*. *Jeers ; jeer-bits.*

Jed'ding-axe. A stone-mason's tool. It has one flat *face* for knocking off projecting angular points, and a pointed *peen* for reducing a surface to the required form. A *cavil*.

The *sax* or *zax* is a slate-worker's axe.

Jeg. A templet or gage, one of several, for verifying shapes of parts in gun and gun-stock making.

Jem'my. 1. (*Fabric.*) A species of Scotch woolen cloth.

2. A small crow-bar.

Jen'ny. (*Spinning.*) A form of spinning-machine invented by Jacob Hargreaves. A playful adaptation of the word *engine*. See SPINNING-JENNY.

Jet. 1. The *sprue* of a type, which is broken therefrom when the type is cold.

2. A solid, dry, black lignite, harder than asphalt and glossy in its fracture.

3. A spout of water in a fountain.

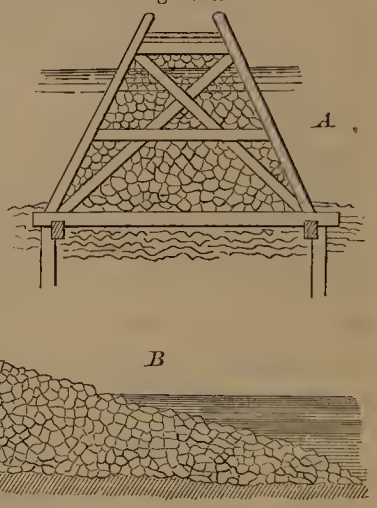
Jet-pump. A pump stated to have been originally contrived to empty the pits of submerged water-wheels. It acts by the pressure of a column of air passing through an annular throat ; or conversely, an annular jet around a central orifice. It has since been used in oil-wells. See EJECTOR.

Jette. The *starling* of a bridge. See STARLING.

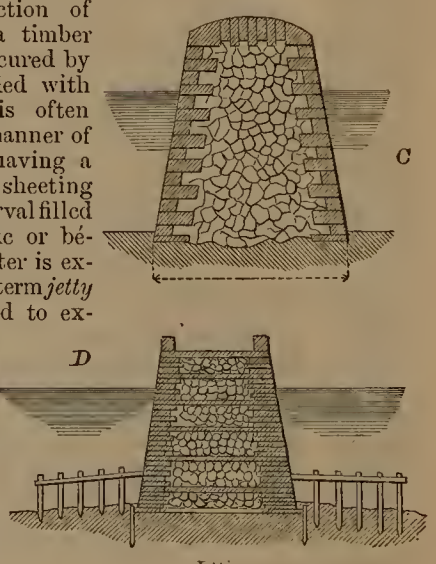
Jet'ting-out. (*Architecture.*) The projection of a corbel or molding beyond the general surface.

Jet'ty. 1. (*Hydraulic Engineering.*) *a.* A construction of wood, rubble-stone, or masonry projecting into the sea and serving as a wharf or *pier* for landing and shipping, or as a *mole* to protect a harbor.

Fig. 2716.



Although limited to no particular form, a very common construction of the jetty is a timber framing *A*, secured by piles or loaded with rubble. It is often built in the manner of a sea-wall ; having a double row of sheeting piles, the interval filled in with rubble or béton. The latter is excellent. The term *jetty* is also applied to expensive and solid erections of masonry, and to *hards* or landing-places for boats.



Jetties.

Teford's jetty *B* at the eastern arm

of Kingstown Harbor, Ireland, is an example of a jetty made of rubble, with a track and parapet of coursed masonry. The foreshore, in most works of this kind, is faced with pitched stones, that is, an outer layer in which the undressed stones are not laid at random, but deposited end on, beginning at the lower edge, and so caused to bind and become mutually sustaining.

Jetties of masonry (*C*) have usually *ashlar facings* and *heartings* of rubble or concrete. The walls filled in with béton will be nearly equal to a solid mass; in fact, béton itself makes a wall of such tenacity that its strength is equal to a homogeneous block. When the ashlar masonry is filled in with earth it requires a bond; when this is of masonry, the counterforts take the form of division-walls, which thus reduce the jetty to a series of compartments. The stones of these horizontal bonding courses should be cramped and joggled together, and the top carefully paved to prevent infiltration.

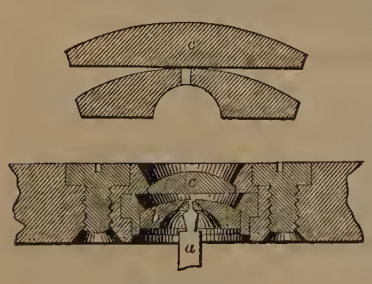
The southern jetty (*D*) of the port of Havre is exposed to violent storms and a powerful littoral current. It exemplifies the ashlar facing, horizontal bonding-walls, rubble filling, paving, parapets, aprons of piles and *picrre-perdue* to protect the foundations from the repercussion of the waves, all executed in a style which has provoked the admiration of those who have understandingly examined it.

In the course of the improvement of the mouths of the Rhine, the northern arm of the Maese is being widened, dredged, and extended into the sea by jetties of about 1,200 feet long and 1,000 yards apart. The mode of their construction is as follows: —

Long fascines are formed of brushwood and placed upon the shore near the site of the works; they are laid in courses, each course being at right angles or oblique to the previous one, until a thickness of about three feet has been obtained; strong stakes are then driven through the mass at frequent intervals, which project about 18 inches at the bottom, and 12 inches at the top. The stakes are then tied together with a willow binding. The work is made in sections measuring about 40 yards by 20 yards. When completed, it is floated to the site of the jetty, and sunk into its place by being evenly loaded with basalt stone, which is brought down the Rhine from quarries near Andernach. Piece after piece of this sort of work is added, until it covers the whole breadth of the base of the jetty for a portion of its length, after which another layer is formed in the same manner, and so on until the requisite hight and breadth of the jetty have been obtained, when a fresh length in advance is commenced. The projecting stakes soon take firm hold of the layers above and below them, the sand silts into the interstices of the brushwood, and in a few years forms an almost impenetrable mass, which, when consolidated, is covered with a paving of large basalt stones.

b. A structure round the piled foundation of a bridge pier.

Fig. 2717.



Watch-Jewel.

2. The part of a building which jets or juts over beyond the ground plan.

Jew'el. 1. (*Watchmaking.*) A crystal or precious stone forming a bearing for the pivot of an arbor; especially used in watches.

The balance jewel always has an *end-stone*, or cap *c*, the balance running on the end of its pivot in order that it may have the utmost freedom; the pivot being but the $\frac{1}{100}$ of an inch in diameter. Diamonds are sometimes used for end-stones, but rarely, if ever, for jewels, it being next to impossible to drill a hole sufficiently small in so hard a substance.

The invention of the process of drilling holes in rubies is attributed to M. Fazio, a native of Geneva, who introduced it into London in the year 1700.

Rubies are used as jewels in good watches. They are the hardest stone that can be drilled, but cheaper stones, such as crystals, garnets, etc., and even glass of hard quality, are often used.

The lower portion of Fig. 2717 represents on an enlarged scale the jeweled pivot-hole for the verge, or the axis of the balance of a marine chronometer. *a* is a hardened steel pivot, which is turned with a fine cylindrical neck, and is made convex at the end; the jewel consists of two stones; one *b*, usually sapphire or ruby, is convex above and concave beneath, of two different curvatures to thin it away in the middle, where the pivot-hole is drilled.

The other, *c*, called the *top-stone* or *end-stone*, is generally a ruby of plano-convex form, or else a diamond cut with facets. The flat side of this touches the end of the pivot.

The rubies or sapphires from which the jewels are made are sometimes split to the requisite thickness, but are commonly slit by a revolving iron disk charged with diamond-powder and oil. When sliced they are ground parallel on a flat plate of copper mounted on a lathe, into the face of which small fragments of diamond have been hammered, and afterwards polished on a similar plate with fine diamond-powder. They are afterwards turned circular and their edges beveled. In turning their faces to concave and convex form a fragment of diamond, mounted on a brass wire, is employed.

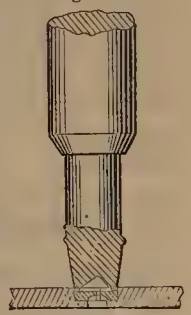
Drilling out the holes is also effected by a splinter of diamond mounted on a wire, this is usually accomplished at two operations, drilling into the two sides successively, after which the interior is polished with a fine steel wire and diamond-powder.

2. A precious stone; a gem. See GEM-CUTTING; SEAL; DIAMOND; STRASS; DOUBLET; BRILLIANT, etc.

The proficiency of the ancient Egyptians in the ornamental arts is well shown in collections of Egyptian jewelry. One ancient collection, dating back to 1900 B. C., is in the possession of the Sultan, and comprises ear-rings, necklaces, seal-rings, and amulets. The workmanship is of the most beautiful description. Many handsome specimens are also in the Museum of the Historical Society of New York. The museums of Europe are rich in specimens from Phœnician, Egyptian, Etruscan, Greek, and Roman sources.

Jew'el-block. (*Nautical.*) A block at the yard-arm of a ship, for the halyard of a studding-sail yard to pass through.

Fig. 2718.



Jewel-Setter.

Jew'el-ers'-red. Crocus.

Jew'el-set'ter. (*Watch.*) A circular steel cutter having a concave end with a circumferential angular edge, which slightly exceeds in circumference the bezel into which the jewel is to be fitted, and by which a circular burr of metal is pushed down upon the jewel.

Jew's-harp. 1. (*Nautical.*) The shackle by which a cable is bent to the anchor-ring.

2. (*Music.*) An instrument having a tongue vibrated by the finger and a frame held against the teeth for a sounding-board.

Jew's-harp Shack'le. A clevis and pin whereby the chain-cable is bent to the anchor.

Jews' pitch. Asphaltum.

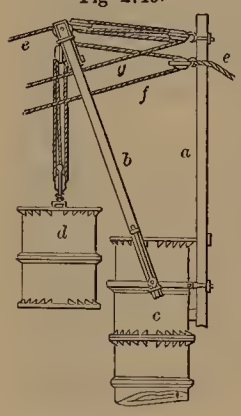
Jib. 1. (*Nautical.*) A large triangular sail set on a stay, forward of the fore stay-sail, between the fore-top mast-head and *jib-boom* in large vessels. It occupies a position between the mast-head and bowsprit in cutters, schooners, and small craft, and does not necessarily run on a stay.

Jibs are known by various names, according to position, etc., as *inner*-jib, *outer*-jib, *standing*-jib, *flying*-jib, *spindle*-jib, *storm*-jib, *jib-of-jibs*, etc.

A *jib-topsail* or *balloon-jib* extends towards the topmast head, and in cutter yachts is sometimes a very large sail.

2. (*Machinery.*) The extended arm of a crane ; or that spar of a derrick which is stepped at the bottom and connected by tackle at the top to the vertical post. The post *a* is maintained vertical by guys, and the tackle affords a means for adjusting the inclination of the *jib b*, the *fall* being carried from the top of the post to a small *crab* on the ground, distinct from the larger crab which operates the hoisting-tackle. See CRANE ; DERRICK.

Fig 2719.



Jib and Post.

The jib of a derrick is stepped, and is adjustable in inclination. The jib of a crane is fast to the frame and rotates horizontally with it, or is journaled to the frame and is adjustable thereon. Sometimes vertically, for hight ; always horizontally for sweep.

Fig. 2719 shows the mode adopted for hoisting the successive sections of the stand-pipe for the East London Water-Works. *a* is a jib-post, secured by a hoop to the standing portion of the pipe *c* ; *b* is the jib ; *d* is the section to be hoisted into place ; *e e* are guy-ropes ; *f g* the falls of the hoisting and the jib-tackles.

Jib-boom. (*Nautical.*) A movable spar running out beyond the bowsprit, for the purpose of affording a base to the jib in large vessels, and to the flying-jib in schooners and smaller craft.

Jib-door. A door made flush with the wall on both sides.

Jib-frame. (*Steam-engine.*) The upright frame at the sides of a marine-engine, connecting the cylinder, condenser, and the framing.

Jib-i'ron. (*Nautical.*) The traveler of the jib. An iron hoop fixed to the jib and sliding on the boom.

Jib-stay. (*Steam-engine.*) A portion of the stay-frame of a marine steam-engine. See JIB-FRAME.

Jig. 1. A handy tool. The name is applied to various devices, and in many trades small and simple machines are called jigs. In the armorer's set of tools we find cited, —

Drilling-jig.	Milling-jig.	Tapping-jig.
Filing-jig.	Shaving-jig.	

2. A trolling bait, consisting of a bright spoon and an attached hook. A ball of light metal on a hook.

Jig'ger. 1. (*Pottery.*) *a.* A horizontal table carrying a revolving mold, on which earthen vessels are shaped. A potters'-wheel ; a *throwing* wheel.

b. A templet or former which is used in shaping the interior of a crucible or other vessel when the clay is upon the wheel. See Fig. 1536, *supra*. See also "Leçons de Céramique," Vol. II. p. 122 *et al.* ; also "Feldspath Porcellan," Weimar, 1835, Figs. 79, 80, 82, Taf. VII.

2. (*Felting.*) To harden and condense a felted fabric by repeated quick blows from rods, or by a platen or platens having a rapid vibratory motion.

A machine for felting fiber by an intermittent rolling action upon the material, which lies upon a table, and is kept warm and wet.

3. (*Nautical.*) *a.* A double and single block-tackle, used for such jobs as holding on to the cable, abaft the capstan, as the cable is heaved in. Also used in hauling home the topsail sheet and other similar work.

b. A small tackle attached to the bight of another rope, to increase the purchase.

c. A supplementary sail rigged on a mast and boom, from the stern of a cutter or other vessel.

d. A small mast erected on the stern of a yawl.

e. A fishing-vessel whose rig corresponds to that of a cutter, excepting a small mizzen in the stern.

f. A weighted line with several hooks, set back to back, dropped into the water, and suddenly jerked upward to catch fish.

4. (*Coopering.*) A drawing-knife with a hollowing blade.

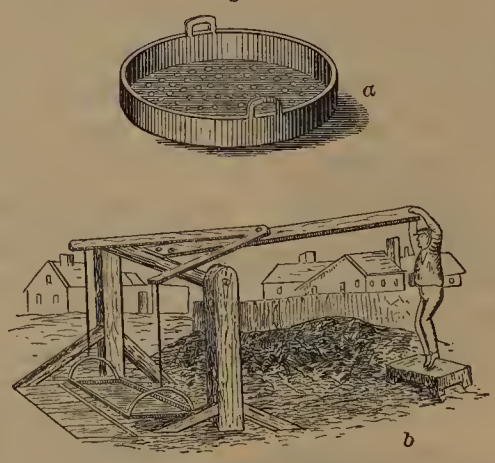
5. (*Leather.*) A machine for graining morocco leather, consisting of grooved boxwood rollers fitted in a frame suspended from the ceiling, and swung backward and forward like a pendulum.

6. (*Metallurgy.*) A riddle or sieve shaken vertically in water, to separate the contained ore into strata, according to weight and consequent richness.

The ancient Iberians washed gold-bearing earth in baskets in the time of Strabo.

The sieve *a* commonly consists of a hoop with handles, and a bottom of sheet-brass, finely perforated. It is used by striking it squarely upon the water, and giving it a semi-rotation simultaneously, to sort the pulverized ore according to gravity ; the ore being lifted by the incoming water from below, and the

Fig. 2720.



Jigger and Jigging-Machine.

heavier portions settling first. The lighter portions are scraped from the top, and the lower stratum removed for smelting or farther concentration.

The object is to keep the particles suspended for a short time in water, so as to give the heavier portions a chance, by rapid subsidence, to arrange themselves as the lower strata in the sieve ; the finest portions pass through the meshes, settle in the vat, and are subsequently washed in a *buddle*.

Several applications of machinery to this purpose may be noticed.

In one (*b*) a heavy sieve is suspended from a lever, which has a horizontal roller for a rocking axis. The lever is worked by a man, who, by a saltatory motion, alternately lifts the *jigger* from the water and allows it to slap down again, raising the ore in the sieve, as has been stated. There are several other applications of machinery, perhaps as nearly allied to this as any other, and may here be noticed.

1. Submerged sieves agitated by steam or water power.

2. Submerged sieves in which the water is introduced in an active current from below.

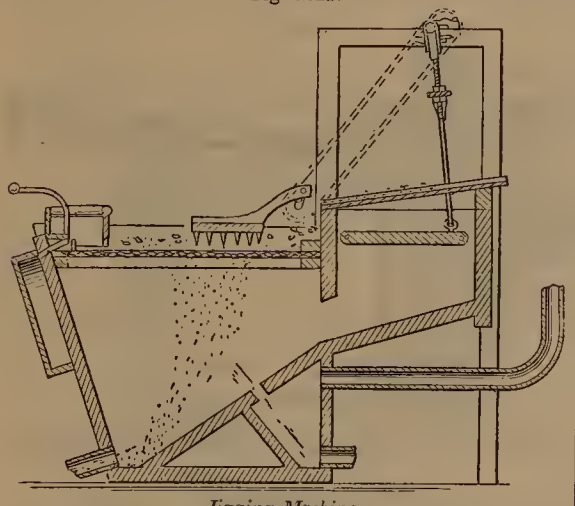
3. A box with a tight wooden floor, with an annular metallic trough pierced with holes, provided with movable sieves. In the middle of this circular system is a cylinder in which a piston plays, the effect being to alternately elevate and depress the level of water which passes through the sieves as it flows, and thus lifts the charges contained therein.

4. The jigging-sieve is attached to the end of a vertically reciprocating rod moved by a lever, which is oscillated by a wiper-wheel on a rotating shaft. The effect is similar to that just described, the layer of ore in the sieve being lifted as the sieve is slapped down into the water, the tendency of the heavier particles to settle first gradually sorting the charge into strata of varying weight and consequent richness.

Jig'ger-knife. A drawing-knife with a blade bent at one end and curved at the other, used by wheelwrights.

Jig'ging-ma-chine'. One in which the pulverized ore falls on to a sieve, where it is agitated by a rake, in water which is caused to pulsate by an intermittent plunger. The small and heavy particles fall through and are sorted by an opposing stream of water; the heavy and larger fall into a ragging-box, and the light are washed off.

Fig 2721.

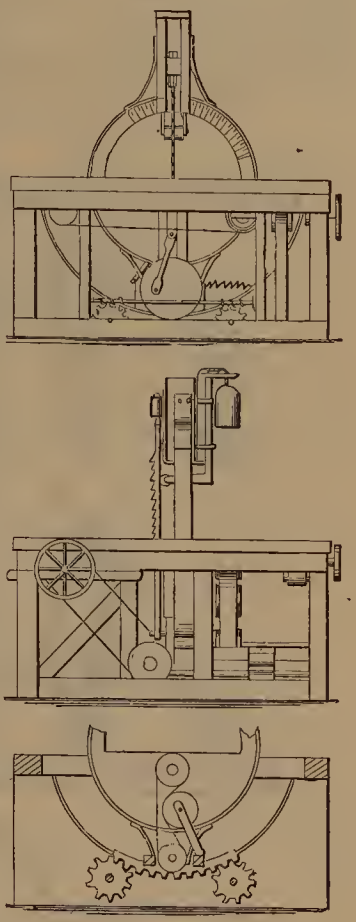


Jigging-Machine.

Jig-saw. A vertically reciprocating saw, moved by vibrating lever or crank-rod, as in Fig. 2722, in which the saw is arranged between two sliding head-blocks, to the upper one of which is attached an index to mark the bevel, a vernier plate being fixed to the circular iron-banded timber to which the blocks are secured by braces. It is moved by a segment of a cog-wheel under the carriage, gearing and working into pinions, and by a pulley-band over a drum.

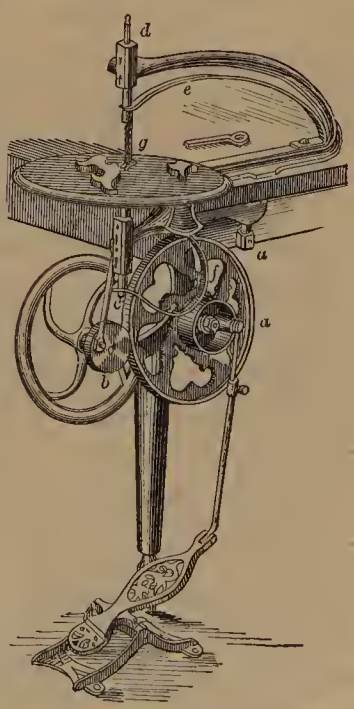
Fig. 2723 is a form of portable jig-saw, which is readily attached to a carpenter's bench or an ordinary table by means of a screw-clamp. The iron arm terminates in the guide *d*, in which works the spindle to which the upper end of the saw is attached, its lower extremity being similarly held in the guide underneath the table. A constant tension of the blade is maintained by the bent springs *e* and *f*. Motive-power is communicated from the treadle, which may be attached, at any convenient point on the floor, to a rod which forms a sleave for a smaller rod, which is connected with the crank of the large wheel *a*. The object of making the rod in two portions is that it may be adjusted to suit any hight of table, and afterward held in position by the set screw. Around the circumference of the wheel *a* is placed a covering of leather, by the friction of which the pulley *b* and the fly-wheel connected therewith are actuated. By means of the pitman, as shown, motion is transmitted to the saw. *g* is an adjustable metallic foot, designed for holding the work in place while being operated upon.

Fig. 2722.



Jig-Saw.

Fig. 2723.



Portable Jig-Saw.

Jim-crow. 1. An implement for bending or straightening rails.

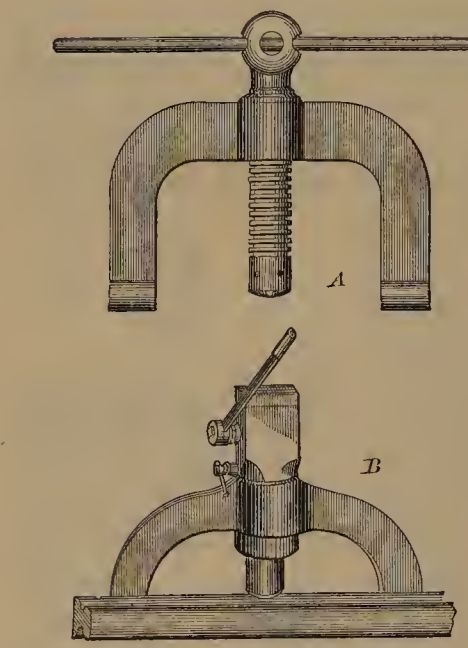
In the examples, *A* is a screw machine, in which the rail lies upon the hooked feet.

B C are hydraulic jim-crows with different modes of presentation, the upper one being a *rail-bender*, and the lower one (*C*) a shaft-straightener, and

may be used on a rod in a lathe. The jack swivels round in the frame so that the handle may be worked in any direction.

2. The *jim-crow* planing-machine is furnished with a reversing tool, to plane both ways, and named

Fig. 2724.



Jim-Crow.

from its peculiar motion, as the tool is able to "wheel about and turn about." The table is moved endways by a quick-threaded screw, which allows the driving motion to be placed at the end.

Jim'my. A short crow-bar.

Jin'gal. A large musket used as a wall-piece in China and India.

Jin'glet. A ball within a spherical bell, which acts as a clapper.

Jin'ny-road. (*Mining.*) An inclined road in a coal-mine, on which loaded cars descend by gravity and elevate empty ones. Also known locally in some parts of England as a *jig-brow.*

Jo'bent-nail. (*Locksmithing.*) A thick-headed nail (*cf.* Eng. *jobber-nowl;* a blockhead; a numskull). A *dog-nail.*

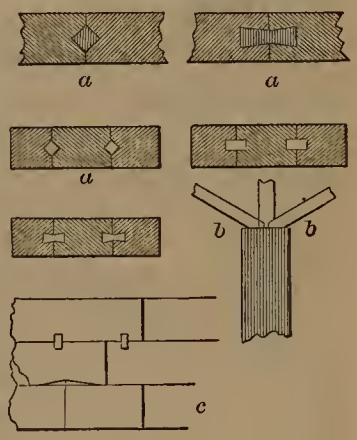
Jock'ey-pad. (*Saddlery.*) A knee-pad on the forepart of a saddle.

Jock'ey-stick. A stick five or six feet long, which is connected at one end to the hame of the *near* horse of a pair, and at the other end to the bit of the off-horse, to keep him at a distance. Used in connection with a single line, the favorite mode of driving a team in most parts of the West, many parts of the South, and worthy of adoption by all.

Jog. (*Machinery.*) A square notch.

Jog'gle. 1. (*Masonry.*) A joint-piece or *dowel-pin a a* let into the adjacent faces of two stones to preserve them in proper relative position. It may vary in form, and may approach in its shape either the Dowel or Cramp (which see).

Fig. 2725.



Joggles.

The stones of the Parthenon at Athens were united by oak joggles.

2. (*Architecture.*) In *pl.* Shoulders *b* on a truss-post, which support the lower ends of *struts* or *braces.*

Jog'gle-beam. (*Carpentry.*) A built beam, the parts of which are joggled together.

Jog'gle-joint. (*Masonry.*) A mode of uniting the stones of ashlar masonry. (*a a*, Fig. 2725.)

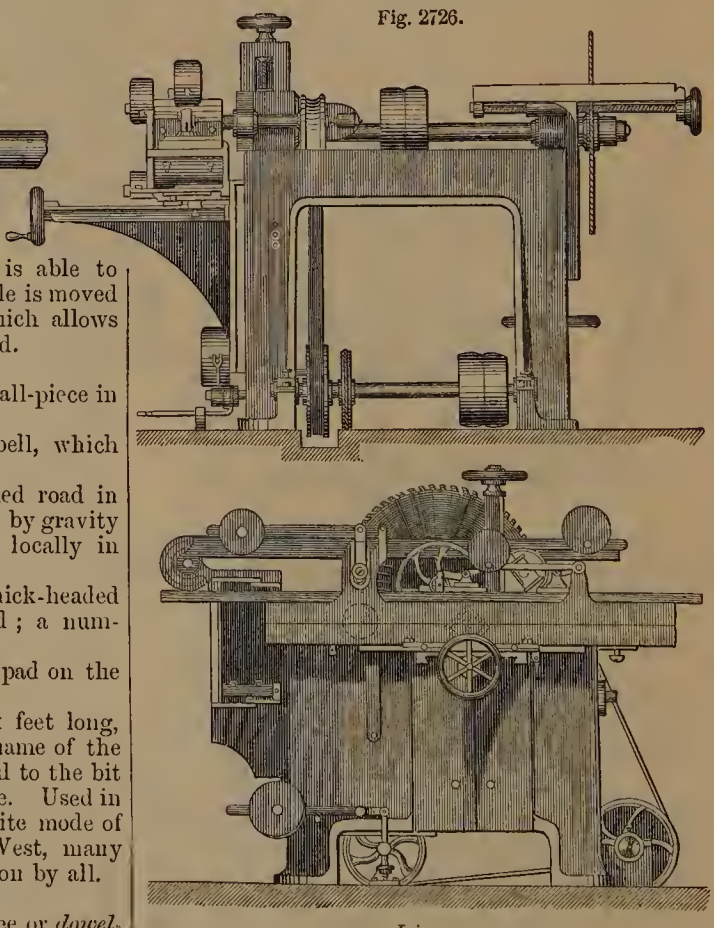
Jog'gle-piece. (*Carpentry.*) The upright member in the middle of a truss. A *king-post.*

Jog'gle-post. (*Carpentry.*) A post having shoulders to receive the feet of struts. See *b*, Fig. 2725; also King-post.

Jog'gle-truss. (*Carpentry.*) A hanging-post truss with only one post.

Jog'gle-work. (*Masonry.*) Work in which the courses are secured by *joggles*, as at *c*, Fig. 2725, so as to prevent their slipping on each other; as the courses of an abutment under the thrust of an arch.

Fig. 2726.



Joiner

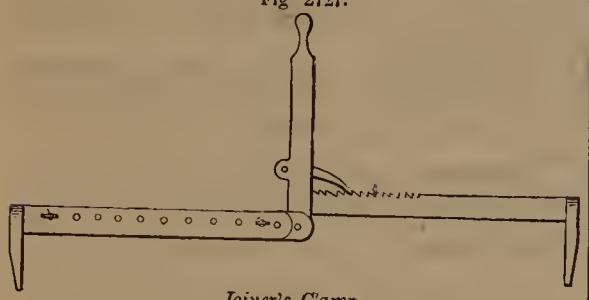
Join'er. A wood-working machine for doing various kinds of work, such as sawing, planing, and thicknessing, mortising, tenoning (single or double), cross-cutting and squaring-up, grooving, tongueing, rabbeting, mitering, molding and beading, chamfering, wedge-cutting, boring, and a great variety of other operations.

Attachable parts adapt the machine for certain duties, such as ripping out or for tenoning, for instance; the illustrations show it as adapted for cross-cutting and for planing or molding.

Join'er's-chis'el. A thin-bladed paring chisel.

Join'er's-clamp. A carpenter's appliance used in gluing up doors and other wide objects; the purpose of the arrangement in the example is to adapt it to fold into a small compass when not in use. See also CARPENTER'S-CLAMP.

Fig 2727.



Joiner's Clamp.

Join'er's-gage. A scribing tool to make a mark on a board parallel to the edge of the latter.

Join'er's-plane. A bench-plane for facing and matching boards.

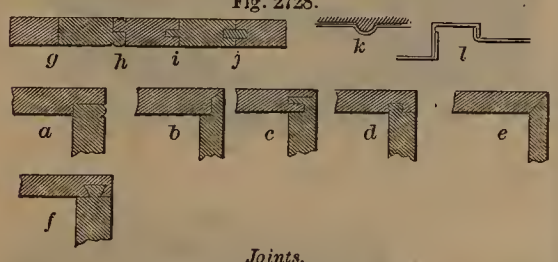
Join'er's Tools. See WOOD-WORKING TOOLS AND MACHINES.

Join'er-y. As distinguished from *carpentry*, the art of framing the finishing work of houses; doors, windows, shutters, blinds, cupboards; hand-railing of stairs, balconies, and galleries; mantel-pieces (if of wood), the construction of permanent fittings, and the covering of all rough timber.

The carpenter is supposed to use the axe, adze, chisel, and saw, and has to make and place the wall-plates, joists, and other floor-timbers, floors, staircase, the woodwork of the roofs, wooden partitions, and those portions of the frames of windows, doors, and skylights which are built into place.

Joint. A junction or mode of joining parts in a structure.

Fig. 2728.



Joints.

1. (*Carpentry.*) A mode of securing together the meeting edges of wooden structures.

The *straight* joint is where the edges make a butt-joint, being planed straight.

a, the bead conceals the joint.

b, may be nailed from both edges, and has a *jog* to prevent slipping.

c, employed for pilasters; it has interlocking jogs, which give a positive hold.

d, employed for skirtings, dadoes, backs, and back linings of windows, doors, jambs, and internal angle-finishing.

e, miter-joint.

f, dovetail-joint.

g, square joint.

h, rabbet-joint, with beads.

i, tongue and groove joint.

j, feather-joint.

Other joints are known by some peculiarity or finish or application, as: *Bracket*, *chamfered*, *covering*, *diamond*, *frontal*, *plain*, *side*, *suspended joints*.

To *joint* is to plane straight the edges of boards.

2. (*Plumbing.*) The sheets of sheet-metal roofing are joined by a *drip-joint k* or a *flashing-joint l* in cases where they are not soldered. The drip is used when the joint is *with* the *current*, and serves as a conductor for water. The *flashing* is a cap strip where the edges of the sheets meet on a projecting ridge. See also ANGLE-JOINT.

A *flush* joint or jump joint is a *butt*-joint covered with a plate on the inner side, called the *butt-plate*.

In a *lap*-joint the pieces overlap each other.

3. (*Masonry.*) The *face-joints* of voussoirs are those which appear on the face of the arch.

The *vertical* joint is between stones of the same course.

The horizontal joint is between courses.

The *coursing-joint* is the joint between the courses of voussoirs.

The *heading-joint* is that between two voussoirs in the same course.

The *flush-joint* is filled up to the face by pointing with mortar.

4. (*Bookbinding.*) The lateral projection of the back to correspond to or cover the thickness of the sides.

See also under the following heads:—

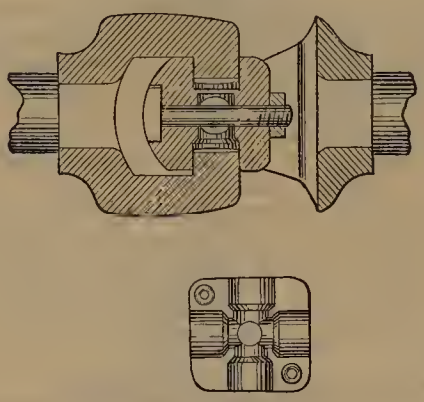
Abutting-joint.
Angle-joint.
Back-joint.
Ball and socket joint.
Bayonet-joint.
Beaking-joint.
Belt-clasp.
Bevel-joint.
Break-joint.
Butt-joint.
Calking-joint.
Carvel-joint.
Clincher-joint.
Close-butt joint.
Cog.
Compass-joint.
Cone-joint.
Coupling.
Coursing-joint.
Dovetail.
Dowel.
Drip-joint.
Elbow-joint.
Expansion-joint.
Face-joint.
Fantail-joint.
Faucet-joint.
Feather-joint.
Fish-joint.
Flange-joint.
Flashing-joint.
Flush-joint.
Folded-angle joint.
Gimbal-joint.
Ground-joint.
Halving.
Heading-joint.
Hinge-joint.
Joggle.
Joint-chair.
Jointer.
Joint-fastening.
Joint-file.
Jointing-plane.
Jointing-rule.
Joint-pliers.
Joint-saw.
Joint-stool.
Joint-wire.
Jump-joint.
Knee-joint.
Lute.
Miter-joint.
Mortise.
Notching.
Overlap-joint.
Pipe-joint.
Plumb-joint.
Prop-joint.
Rabbet-joint.
Rail-joint.
Rivet-joint.
Roll-joint.
Rule-joint.
Rust-joint.
Rustic-joint.
S-joint.
Scarf-joint.
Shift-joint.
Splice-joint.

Square-joint.
Strap-joint.
Surface-joint.
Sypher-joint.
T-joint.
Tenon-joint.
Thimble-joint.
Toggle-joint.
Tongue and groove joint.
Union-joint.
Universal-joint.
Weld-joint.

Joint-chair. (*Railroad.*) A railway chair which supports the ends of abutting rails.

Joint-coup'ling. A form of universal joint for

Fig. 2729.

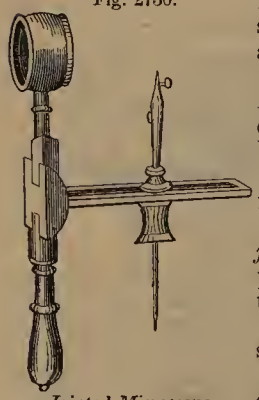


Joint-Coupling.

coupling sections of shafting. In the example, the pivoting points enter recesses cast in the clamping-iron, which is made in two parts, held together by a bolt. See also JOINT, for list of varieties.

Joint'ed-mi'cro-scope. A pocket microscope in which the handle and lens-holder shut down against the slide on which the object pliers are adjustable.

Fig. 2730.



Jointed Microscope.

Join'ter. (*Masonry.*) *a.* A tool for filling the mortar cracks between courses of bricks. A *pointing* tool.

b. A tool for marking the mortar-joints.

2. (*Coopering.*) The *stave jointer* is a large stationary plane on which the edges of the staves are worked.

The *heading jointer* has a straight-edged bit.

The *backing* or *side jointer*, otherwise called the *over-shave*, has a concave-edged bit, and is used for dressing the backs of staves.

The *inshave* has a convex-edged bit, and is used for dressing the inner faces of staves.

3. A bent strip of iron inserted into a wall to strengthen the joint.

Joint'er-plane. (*Coopering.*) A plane five or six feet long, its lower end resting upon the ground, and its upper end supported upon a prop, the inclined sole being presented upward for the staves, which are jointed thereon.

The Hindoos and Chinese bore a hole through the front of a plane for a stick whereby a boy assists by pulling the plane across or along the work. When the plane is very large, the Chinese place it at an angle, resting one end on the ground, in the manner of our cooper's *jointer*.

Joint-fas'ten-ing. (*Railway.*) A fish-bar or other means of locking together the adjacent ends of two railway rails.

Joint-file. A small file without taper, and circular in its cross-section. It is used for dressing out the holes for the joint-wire in snuff-boxes, etc., and in preparing the apertures for the pintles of hinges.

Joint-hinge. A strap-hinge. See HINGE.

Joint'ing-plane. (*Joinery.*) A plane with a long stock, used to true the edges of boards or staves which are to be accurately fitted together. It is 2 feet 6 inches long, and the work is called *shooting the joints*.

Joint'ing-rule. (*Bricklaying.*) A straight rule about six feet long, used by bricklayers in marking with white paint along each joint of the brick-work. Otherwise called *penciling*, and designed to render the joint conspicuous.

Joint-pipe. (*Gas-apparatus.*) A short section of pipe, forming a connection between two lengths, and usually having threaded sockets into which the parts are screwed.

Joint-pli'ers. A pliers adapted for securing the joints of compasses and similar instruments; also one by which the hinging of watch-cases is assisted.

Joint-saw. A saw with a curved working face, used in making the joints of compasses and other similar work.

Fig. 2731.

Joint-Saw.

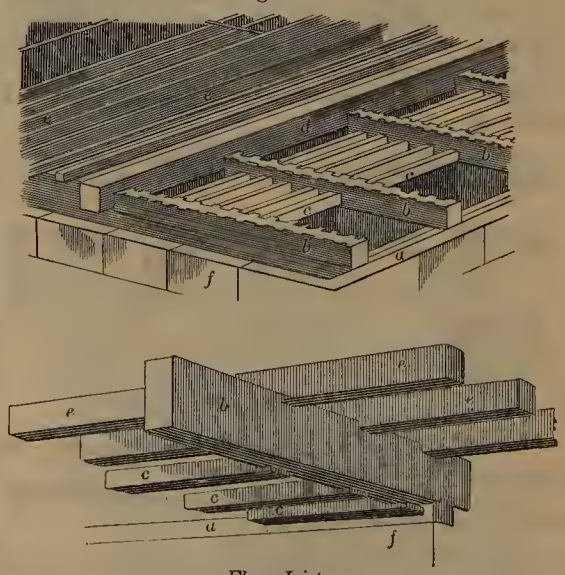
Joint-stool. A block holding up the ends of parts which belong in apposition, as railway rails, ways of vessels, etc.

Joint-wire. (*Watchmaking.*) The tubular wire, sections of which form the joints of watch-cases, lockets, etc.; a piece is hard soldered to each leaf, and a solid wire runs through to form the pintle. It is drawn upon a piece of steel wire, one end being tapered off with a file, so that the tube and wire are grasped together by the dogs and drawn after the manner of a solid wire.

Joist. (*Carpentry.*) A horizontal timber supporting a floor or ceiling, one or both.

Single flooring is formed with joists reaching from wall to wall, where they rest on *plates a* of timber built into the brick-work. The floor-boards are nailed on the upper edges of the joists, whose lower edges receive the lathing and plastering of the ceil-

Fig. 2732



Floor-Joists.

ings. Double floors are constructed with stout *binding joists b b*, a few feet apart, reaching from wall to wall, and supporting *ceiling joists c c* which carry

the ceiling, and *bridging joists* *c e* on which are nailed the floor boards.

When the main timbers of the floor are girders *d* which rest on the wall plates and support the *binding joists* *b b*, the floor is called a *framed floor*. The binding joists *b b* support the bridging joists *e e* and ceiling joists *c c* as before.

The *trimming* joists are short joists into which trimmers are mortised. Trimmers are pieces around a fire-hearth or a hatchway, where the continuity of the joists is broken.

The strength of joists, of equal thickness, is as the square of the height. A joist 4 × 6 has one quarter the strength of a joist 4 × 12. The latter is only twice as large.

Timber is weakened by sawing. A floor of 16 feet bearing, supported by 12 joists 8 inches square, 1 foot apart, is stronger than a similar floor of 24 joists, 8 × 4, placed edgeways, 6 inches apart. The quantity of timber is the same in both cases.

Jol'ly-boat. (Dutch *jol ;* Danish *jolle ;* a yawl.) A small boat used for the general miscellaneous work of a ship, such as bringing off marketing, etc.

A boat of this kind attached to United States vessels of war is called a *dingy*. It is clinker-built, from 16 to 20 feet long, with a beam from .33 to .29 of its length.

Jour'nal. (*Machinery.*) That portion of a shaft which rests in the bearings.

Jour'nal-bear'ing. (*Machinery.*) The support of a shaft or axle, generally boxes or brasses in a *pillow-block*.

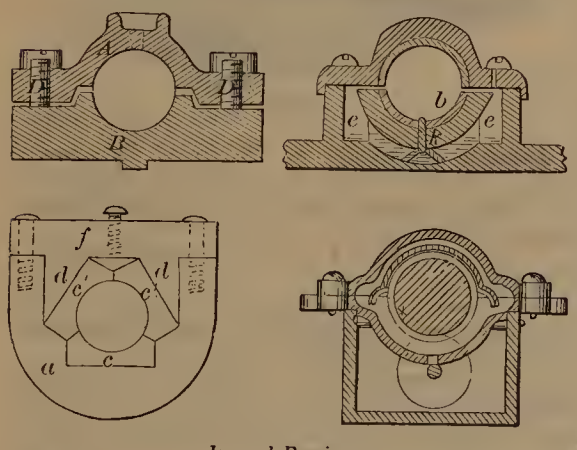
Fig. 2733 shows four varieties of journal-bearings for machinery.

In one *A* is the cap, *B* the pillow ; *D D* are screws with set nuts for adjustment.

In another, the lower half *b* of the box rests in an oil reservoir *c*, from which the lubricant is led up by wicking *k*.

In the lower figure to the left, the bearing is made in three parts, *c c' c'*, movable by means of the wedge-

Fig 2733



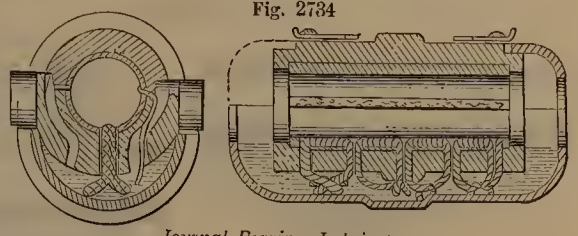
Journal-Bearings.

faces *d d* of the block *f* towards a common center to compensate for wear.

The right-hand figure below shows a shield above the journal to prevent the oil from being thrown through the joint between the two parts of the box.

Fig. 2734 shows a removable oil-reservoir, which can be detached without disturbance to the journal-box. The ends extend beyond the box, with caps to fit over such projections. An oil passage leads to the top of the box, for the conveyance of oil to the top of the box by means of a capillary substance,

Fig. 2734



Journal-Bearing Lubricator.

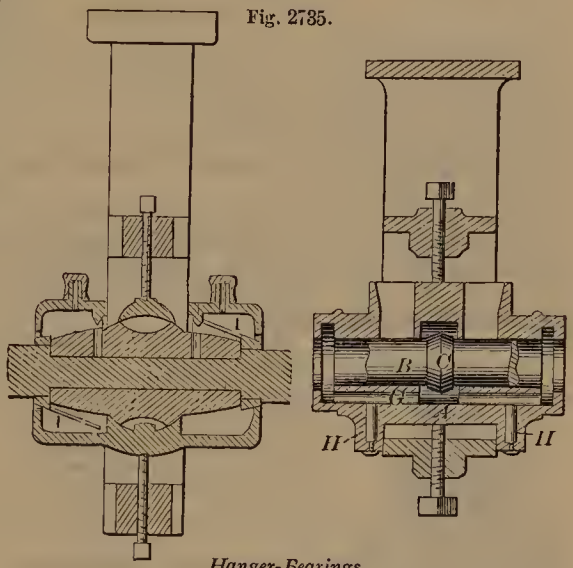
and a like passage on the other side of the box conducts back to the reservoir any surplus oil carried over by means of rapid motion.

Fig. 2735 shows two forms of journal-bearings in suspended hangers.

In the one to the left, the box is surrounded by a shell whose lower portion contains the oil which is raised by inclined wires in the shoulders of the shaft. The oil is carried up to the points which depend from the upper portion of the shell, and it then drops into the oil-holes of the box.

In the other view, the oil is carried up by the col-

Fig. 2735.



Hanger-Bearings.

lar *C*, distributes right and left, and returns by the longitudinal channels *G*. *H H* are sediment-boxes.

Fig. 2736 shows a number of bearings for axles.

Above, to the left, is one in which the axle-arm *F* rests on a wheel *D* which revolves in the oil-reservoir.

To the right of this figure is one with anti-friction rollers around the shaft ; these are prevented from shifting endways by the circular flanges *F* on the axle and in the box which project within the peripheral grooves in the rollers *D*.

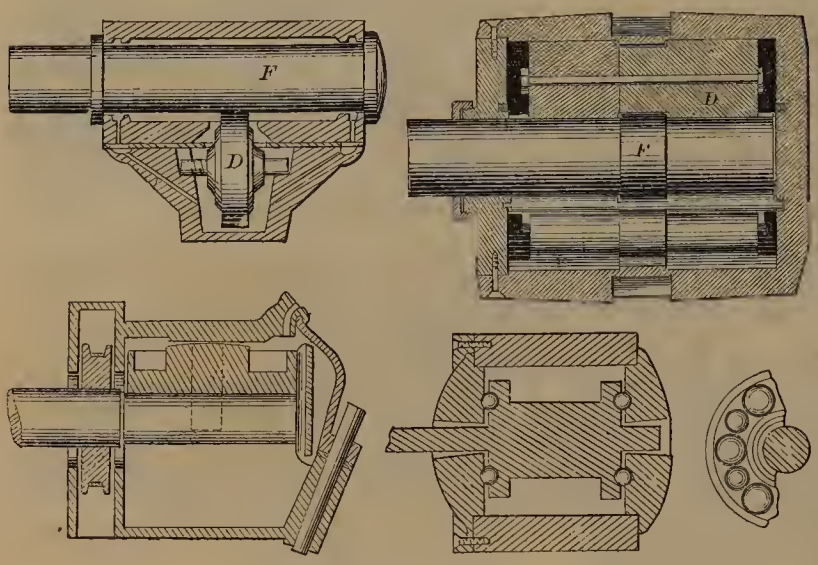
The circular system of anti-friction wheels for a journal-bearing is described in Tate's English patent, 1802.

Below this figure is one in which the anti-friction balls are used. The casing has annular grooves in which balls of different diameters are placed alternately, so that the large balls will all turn in one direction, and the small balls will keep the large ones in position.

To the left, below, is a view of a railway car axle and box. See CAR AXLE-BOX.

Fig. 2737 shows a journal-bearing for a vertical shaft, with journal-box *a* in one piece. The spindle *b* is inserted from below, and coupled by a screw coupling or otherwise. The bolt above affords a

Fig. 2736.



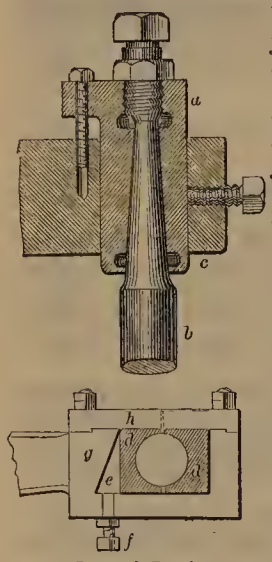
Bearings of Journals of Axles.

bearing for the end of the spindle, and the box has a receptacle for lubricant. Other lubricating chambers may be provided, as shown at *e*.

The lower portion of Fig. 2737 shows an adjustable box consisting of two portions *d d*, inside the strap *h* of a connecting rod.

The lubricity of oils or their comparative fitness for the lubrication of bearings and packing-boxes may be ascertained by a machine which determines the amount of frictional motion that is necessary to produce a given temperature.

Fig. 2737.



Journal-Bearing.

Girard's *palier glissant* employs water to act, first, by its pressure, to lift the journal to be lubricated; and, secondly, by its fluidity to form a liquid bed or cushion between the journal and its box, on which the journal may rest in its revolution without touching the metal of the box at all.

Water-bearing for steps and shafts is described in Bramah's English planing-machine patent, 1802. He describes it as a liquid bearing for steps of vertical shafts, and makes it adjustable by pumping in liquid. Known also as *palier glissant : hydraulic pivot.*

Babbitt's Anti-attrition Metal. Melt 4 lbs. copper; add, by degrees, 12 lbs. best banca tin, 8 lbs. regulus of antimony, and 12 lbs. more of tin. After 4 or 5 lbs. tin have been added, reduce the heat to a dull red, then add the remainder of the metal as above.

This composition is termed *hardening;* for lining, take 1 lb. of this *hardening*, melt with it 2 lbs. banca tin, which produces the lining metal for use. Hence, the proportions for lining metal are 4 lbs. of copper, 8 of regulus of antimony, and 96 of tin. See ALLOY.

Devlan's compositions for lining journal-boxes are various combinations of vegetable fiber, graphite, steatite, gum, bitumen; or paper pulp and silicate of soda or potash; or vegetable fiber, graphite, steatite, and silicate of an alkali.

Metaline is a material formed of metals, oxides of metals, and organic matter, reduced to powder, compounded with wax, gums, or fatty matters, and subjected to heavy pressure, so as to form solids of proper shape to form boxes and bearings for shafts or axles.

The following compositions are stated: —

Lignum vitæ and spermaceti.

Ivory-dust and spermaceti.

Tin and petroleum residuum.

Zinc and caoutchouc.

Plastic bronze and caoutchouc.

Type-metal and caoutchouc.

Anthracite and tallow.

Oxide of tin and beeswax.

Jour'nal-box. The carrier of a journal. See JOURNAL-BEARING; AXLE-BOX; CAR AXLE-BOX.

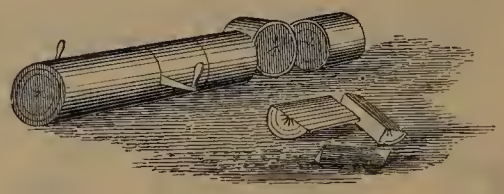
Jour'nal-box Met'al. See BABBITT-METAL; ALLOY.

Jour'ney. A corruption from JOURNAL (which see).

Juc'ten. A name by which *Russia leather* is known. *Juften.* See RUSSIA LEATHER.

Jug'gle. A block of timber cut to a length, either *in the round* or split.

Fig. 2738.



Juggles.

Jump. (*Forging.*) *a.* To upset by endwise blows, which contract the object in length, but thicken and spread it laterally. Applied to *jumpers*, tamping bars, axes, etc. See UPSETTING.

b. To attach by a *butt-weld*, in contradistinction to a *lap-weld.*

A transverse piece attached by welding is said to be *jumped on.* If formed from a portion of the rest, it is said to be *headed on.*

c. A gun-barrel made of a ribbon of iron, or laminated iron and steel, coiled around a mandrel at a red heat, then raised to a welding heat and placed on a cylindrical rod, which is struck heavily and vertically on the ground, is said to be *jumped.* The effect is to cause the edges of the ribbon to unite, a junction which is completed by the hammer on an anvil, the mandrel retaining its position. Such barrels are said to be *twisted.* The *twist* is *stub*, *wire*, or *Damascus*, according to the mode of manufacture of the ribbon. See TWIST; GUN-BARREL.

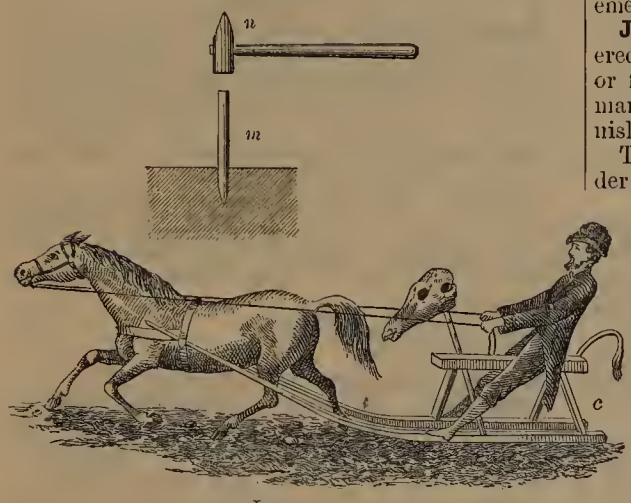
2. (*Mining.*) A fault or dislocation of a vein or lode.

Jump'er. 1. (*Quarrying.*) *a.* A quarryman's boring-tool. A rod of steel, or pointed with steel, which breaks the rock by being alternately jumped

up and down to form a hole for blasting or for an artesian well.

b. A steel-faced chisel *m* held by one man while another strikes it with a hammer *n*. Used in drilling holes in rock for blasting or splitting.

Fig 2739.



Jumpers.

2. A cheaply formed sled *c*, in which supple pieces of wood form the shafts and runners, and support a box or trestle in or on which the person rides.

3. (*Horology.*) *a.* A spring used in repeating-clocks to assist the motion of the star-wheel.

b. A species of click in the repeating-watch, preventing the motion of a wheel in either direction.

4. (*Planing.*) A plow-bit or machine-jointer, having an intermediate bearing upon the board.

5. (*Husbandry.*) A plow having an upturned cutter in front of its share, and which, going below the share, prevents its being caught on roots, etc.

Jump-joint. 1. A butt-joint.

2. A *flush*-joint, in which the plates or planking make a smooth face. In shipbuilding it is equivalent to *carvel*-build.

Jump-seat. (*Vehicle.*) A kind of open buggy which has a shifting seat or seats. For instance, it may be arranged as a double or single seat vehicle. In the former case, the main seat is moved over backwardly, and the extra seat brought up in front. As a single-seat vehicle, the main seat is thrown into a central position, the extra seat being placed below the other one.

Junc'tion-plate. (*Boiler-making.*) A welt or break-joint plate riveted over the edges of boiler-plates, which make a butt-joint.

Junc'tion-rails. (*Railroad-engineering.*) Switch rails which connect tracks.

Junk. 1. (*Vessel.*) (Dutch, *jonk*, perhaps from Chinese *yong*, the sea.) A vessel employed by the Chinese, Japanese, and Malays in navigating their seas.

It is the largest kind of Chinese vessel. It has no prominent stem or keel. The bow on deck is square, and the anchors are on each side of the bow. The stern is full, the rudder suspended, and at sea is lowered beneath the depth of the bottom of the vessel. The immense masts are in one piece, the lug-sails are sometimes of matting.

2. Old cable and rope cut into lengths, to make *mats*, *swabs*, *gaskets*, *sinnet*, *oakum*, etc.

Junk-ring. (*Steam-engine.*) *a.* A metallic ring which is screwed down upon and confines the hemp packing of a piston.

b. A steam-tight packing around the piston of a steam-engine.

Junk-wad. (*Ordnance.*) A wad made of oakum bound with spun-yarn, and filling the bore of the gun. It is placed between the charge and the ball.

Ju'ry. (*Nautical.*) A term applied to temporary structures, such as masts, rudders, etc., used in an emergency.

Ju'ry-mast. (*Nautical.*) A temporary mast erected in place of one that has been carried away; or for navigating a vessel to a place where the permanent equipment of masting and rigging is furnished.

The temporary rig is termed *jury-rigged;* a rudder of the same character, a *jury-rudder.*

Jus'ti-fi-ca'tion. 1. (*Printing.*) The adjustment of distance between the letters in the words and the words in a line, so as to avoid any glaring disproportion, and make them fill the measure.

2. (*Bookbinding.*) Attention to keeping the matter of pages in exact register or correspondence, to secure even margins.

Jute. (*Fiber.*) The fiber of *Corchorus capsularis* and *C. olitorius*, which is used in India for making gunny-bags, matting, rope, and other coarse fabrics.

In the manufacture of fabric from this article, the jute, after being taken from the bale, is sprinkled with oil and water, spread out on a table for a day or two, and then passed between rollers to render the fibers soft and pliable. It is next passed between toothed rollers, which bring the fibers nearly parallel, arranging them into a species of ribbon or sliver, which is again passed between two rollers with finer teeth than the preceding pair. These two machines are called the *breaker-card* and the *finisher-card.* The slivers thus formed are received into cans and subjected to the action of the *drawing-frame*, which is similar in its operation to that employed in the cotton manufacture, drawing out, narrowing, and thinning the slivers. The sliver is then slightly twisted and wound upon bobbins by the *roving-machine*, and afterwards spun by a *throstle;* the throstles making from 3,000 to 4,000 revolutions per minute.

The finished yarn for the warp is wound on large bobbins in the *winding-machine*, and placed on the loom beam by the *beaming-machine;* the weft yarn is wound on the pirns of the shuttles by the *pirning-machine.* The loom and shuttle are larger and stronger than those employed for weaving cotton, the fabrics made being generally coarser.

The finest jute yarns bear the lowest numbers, while in cotton the reverse is the case.

Jute-twine is sized with glue-water, starch, tallow, and China clay.

Crossley's patent floor-covering has a foundation of coarse jute coated with a layer of wool, and the two united by felting. The surface is finished by printing.

In Monach's process for preparing jute as a substitute for wool, the jute or jute-yarn is boiled for two hours in a solution of caustic alkali of a gravity of 60° to 80° Twaddell. After washing, it is steeped a short time in a weak solution of sulphuric acid to neutralize the alkali, and is then washed and dried.

Jut'ting-out. (*Architecture.*) A projection; said of windows, corbels, cornices, etc.

Jutty. (*Architecture.*) A projecting part of a wall, as of a prominent course.

Jut-win'dow. (*Carpentry.*) A bow-window, projecting from the face of a building. A *bay-window.*

K.

Ka'jak. The boat of the Esquimaux. It is from 18 to 20 feet long, 18 inches broad in the middle, tapering to both ends, and about a foot deep. It has no outriggers, and is difficult to manage. It is covered with skins, and closed at top with the exception of a hole in the middle, which the boatman occupies, sitting on the floor of the boat.

The *kajak* is the men's boat. The *umiak* is the women's boat; has a flat bottom, and is much larger. It is made of slender laths, fastened with whalebone, and covered with seal-skin.

Ka-lei'do-phone. An instrument invented by Professor Wheatstone, to illustrate the phenomena of waves of sound. An elastic thin bar is fixed by one of its extremities, and at its free end carries a silvered or polished ball; a ray of light is reflected from this ball, and when the thin plate is put in vibration, the fine point of light describes various curves, corresponding with the musical notes produced by the vibrations.

Ka-lei'do-scope. An optical instrument, invented by David Brewster, 1814–17. An arrangement of mirrors produces a symmetrical reflection of beautiful images, derived from the association of pieces of colored glass, which assume new relations as the tube is slowly rotated.

This instrument is first noticed by Baptista Porta in his "Natural Magic," under the name of polyphaton. Kircher describes a similar invention of his own, but the application of two reflectors so inclined to each other as to form symmetrical images, changing as the instrument is rotated, was invented by Brewster.

"He subsequently found means to obtain multiplied images of such objects as flowers, trees, and even persons and things in motion, and thus the importance of the instrument was greatly increased. For this purpose, he caused the two mirrors to be fixed in a tube as before, but this tube was contained in another, from which, like the eye-tube of a telescope, it could be drawn at pleasure towards the eye. At the opposite end of the exterior tube was fixed a glass lens of convenient focal length, by which were formed images of different objects in the upper section, and which, being multiplied by successive reflections from the mirrors, produced in the field of view symmetrical patterns of great beauty. The properties of the instrument have been greatly extended; and when it is so constructed that there may be projected on a screen a magnified image of the whole pattern, and the tube is supported on a ball and socket joint, the figures in its field may be easily sketched by a skillful artist." —Timbs.

Kal'lif-thor'gan. A musical instrument played as a piano, and imitating the effect of a violin, violoncello, and double-bass.

Kal'muck. (*Fabric.*) A coarse, shaggy cloth, resembling a bear-skin.

A coarse, colored, cotton cloth made in Persia.

Kal'so-mine. A mixture of clear glue, Paris white, and water, laid on to a wall as whitewash. Commence by soaking 4 ounces of glue in a quart of warm water for 24 hours; then add a pint of water, and the tin vessel should be placed in a kettle of hot water over a fire, the glue being agitated till it is thoroughly dissolved and the solution quite clear. Put 5 or 6 pounds of powdered Paris white into a large bucket, and add hot water sufficient for the mixture to be of the consistency of cream; color according to taste. Then mix the glue-water with it, stir it well, and paint the walls with the mixture with the usual whitewash-brush.

Kamp-tu'li-con. A floor covering made of india-rubber, gutta-percha, and cork. The two former having been liquefied, the other is added in the form of fine dust. (Galloway's English patent, February 14, 1844.) The mixture, while warm and soft, is pressed into sheets between rollers. It is very elastic, and is printed like floor-cloth.

Ka'o-lin. The Chinese name for porcelain clay; which is derived from the decomposition of felspar. In the Chinese manufacture of porcelain the *kaolin* is mixed with a fusible earthy matter, call *petuntse*. See Porcelain.

Kas. 1. A horsehair sieve.

2. A negro drum.

Kath'e-tom'e-ter. See Cathetometer.

Keck'ling. (*Nautical.*) A mode of protecting a cable or hawser from chafing at the hawse-hole, or from being chafed by ice, etc., by means of a wrapping or serving of rope, small chain, or other envelope.

Kedge. A small and portable anchor, used in warping and other of the lighter duties of an anchor. See Anchor.

Keel. 1. (*Shipbuilding.*) *a.* The lower longitudinal beam of a vessel, answering to the spine, and from which the ribs proceed.

In wooden vessels, an additional timber beneath is called the *false keel.*

A timber resting on the flooring timbers and above the keel is the *keelson.*

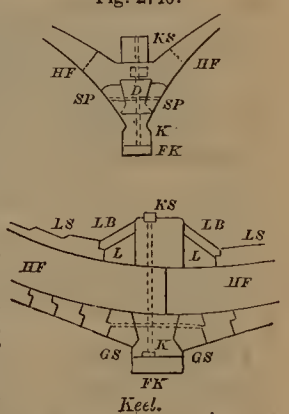
Timbers secured parallel to the latter are the *sister-keelsons*, or *side-keelsons.*

Heavy timbers resting on the timbers before mentioned, and lying athwartships, are *cross-keelsons*, for sustaining the boilers and engines of steamships.

The *bilge*-keel is a longitudinal piece fastened on the bilge to protect it, or to prevent rolling, in the case of iron vessels without true keels.

The keel is *laid* upon blocks whose upper surfaces form an angle of about 3° with the horizon. The blocks are about three feet high and four feet apart.

Fig. 2740.



Keel.

In England the keel is usually of elm, the pieces being scarfed together to attain the requisite length. In a first-rate line-of-battle ship the keel is 20 × 20 inches. American elm does not suit for the purpose, and white oak is used.

A *sliding* keel is a board amidships, working in a trunk in the line of the keel and extending from the bottom to the deck. It is lowered to form a leeboard for a vessel when under canvas.

The upper portion of Fig. 2740 shows, in cross-section, the keel in the cant frames.

K, keel.	*SP*, stepping-pieces.
FK, false keel.	*HF*, half-floors.
D, deadwood.	*KS*, keelson.

The lower figure shows the keel nearer to midship.

K, keel.
KS, keelson.
FK, false keel.
HF, half-floors.
GS, garboard-strakes.
L, limbers.
LB, limber-boards.
LS, limber-strakes.

b. A small coal-carrying craft, used on the river Tyne.

2. A broad, shallow, cooling vat.

Keel-boat. A large, covered boat, used on American rivers. Before the time of steamboats, keel-boats were used for passengers and merchandise, being floated down stream and *poled* up stream.

Keel-fat. A cooler for wort, etc.

Keel'son. (*Shipbuilding.*) A longitudinal piece above the floor-timbers, binding them to the keel.

The *sister-keelsons* lie on each side of the keelson. Also called *side-keelsons.*

The *intercostal-keelson* is a short piece between frames.

Rider-keelsons are auxiliary keelsons placed above the *main-keelson* to give additional strength. See KEEL.

Keep. (*Architecture.*) The tower or place set apart in a castle for the confinement of prisoners. A *redoubt.*

Keep'er. A ring, strap, pocket, or the like device for detaining an object; as, —

1. (*Harness.*) The *keeper* of a buckle-strap; a loop which slips upon the end of the strap, or into which the strap slides.

2. A ring worn on the finger to keep a larger one on.

3. A jam nut.

4. The box on a door jamb into which the bolt of a lock protrudes, when *shot.*

5. The armature of a magnet. A piece of iron which connects the two poles.

6. The mousing of a hook, which prevents its accidental disengagement.

7. The gripper of the flint in a flint-lock.

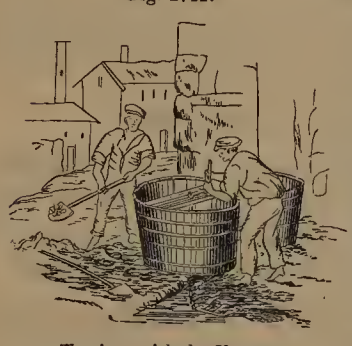
Keeve. A large vessel or vat, used for mashing, fermenting, or storing beer. See BECK; VAT.

For holding a bleaching liquor or alkaline lye. See KEIR.

For elevating ores. See CORF.

An iron-bound tub of a truncate, conical form, set upon the smaller end, and used for collecting the fine grains of copper. In use it is kept half full of water, and the contents agitated by a shovel till the heavier particles seek the bottom, leaving the water to be dipped out and the refuse lighter upper stratum to be removed.

Fig. 2741.



Tossing with the Keeve.

In the illustration the *keeve* is shown with a central shaft and a paddle, which is revolved until all the mineral contents are involved in the gyration of the water, when the action is moderated and the heavier particles gradually assume the lower position and eventually reach the bottom. The action is called *tossing* or *tozing.* Other contrivances in which the comminuted ore is agitated in water are known as jiggers, etc. See METALLURGY.

Keir. A vat for holding a bleaching liquor. The alkaline vat of a bleachery. See BUCKING-KIER.

Kel'lach. A wicker sledge or cart used in Scotland.

Kem'e-lin. A brewer's vessel.

Ke-men'geh. An Arab violoncello, with two strings.

Kemps. 1. Impurities of fur; that is, knots and hairs which do not possess the felting property.

2. The coarse, rough hairs of some grades of wool.

Ken'net. (*Nautical.*) A *kevel* or large cleat.

Ken'nets. A coarse cloth made in Wales.

Kent-bu'gle. The key-bugle invented by Logier early in this century, and named after the Duke of Kent, the father of Queen Victoria. It has six keys, and is the predecessor of the great tribe of cornets.

Kent-ledge. Pigs of iron for permanent ballast, laid over the keelson-plates.

Ke'per. A German twilled linen goods resembling *marsella. Kofer.*

Ker'a-tome. A surgical knife used in the operation for *artificial pupil.* Also called *iridectome* or artificial-pupil knife. It is spear-pointed, double-edged, and may be straight or angular. It is used for making an incision through the cornea into the anterior chamber, and by slight movements of its cutting edges, upward or downward, the wound is made of proper dimensions, after which the operation is completed with other instruments. Also used in operations for cataract.

Kerb. (*Masonry.*) Called also curb.

1. The assemblage of stones surrounding the mouth of a well or similar opening. See CURB.

2. The line of stones set on edge which separates a foot pavement from the gutter or carriage-way.

Kerf. The slit or notch made by a saw.

Kerf'ing-ma-chine'. A machine for sawing a series of parallel kerfs on one surface of a board, in order to enable it to be bent.

It consists of a table and a series of circular saws upon a horizontal mandrel, the latter being vertically adjustable, so as to allow the saws to project above the surface of the table to an extent equal to the desired depth of kerf.

Ke'rite. A compound invented by Austin G. Day (patent October 9, 1866), and by him termed *kerite* or *artificial caoutchouc,* and in which the raw caoutchouc or rubber is replaced by tar or asphaltum, which, combined with animal or vegetable oils, is vulcanized by sulphur, the product closely resembling rubber, the hard and soft varieties being produced by different proportions, etc. The principal use of kerite has been as an insulating material in telegraphy.

Day, in his patent, gives the following formulas. Parts by weight. Heats to 260°, gradually increases to 300° F.

a. Linseed-oil, 2; cotton-seed oil, 1; raw turpentine, 2; sulphur, 2. Time, 1 hour.

b. Linseed-oil, 2; castor-oil, 1; liquid coal-tar, 2; petroleum, 1; turpentine, 2; sulphur, 2. Time, 30 minutes or more.

c. Linseed-oil, 2; petroleum, 1; crude turpentine, ½; sulphur, 4. Time, 35 minutes.

Ke'rite-wire. Wire used in telegraphy, insulated by a covering of *kerite.*

Kern. 1. (*Printing.*) The part of a letter which overhangs the shank. It occurs more frequently in *italic* than in Roman: "*jolly old fag*" embraces the kerned letters of an *italic* font.

2. (*Milling.*) A hand-mill for grain. See QUERN.

Ker'sey. (*Fabric.*) A probable corruption of Jersey, whence it came. A coarse ribbed cloth made from wool of long staple.

Ker-sey-mere'. (*Fabric.*) A light woolen twilled goods with an oil finish, for men's wear.

Named from *Kersey*, in Yorkshire, England. *Cassimere.*

Ker-sey-nette'. (*Fabric.*) A thin woolen cloth. *Cassinette.*

Ketch. (*Vessel.*) An almost obsolete form of two-masted vessel, carrying a tall, square-rigged main-mast forward, and a shorter fore-and-aft rigged mizzen abaft.

Being a favorite form of mortar vessel, we frequently read of *bomb-ketch* in the wars of a past age.

Ket'tle. A metallic vessel in which water or other liquid is boiled. In sugar-houses kettles are arranged in rows called *batteries.* Capacities and sizes of sugar pans and kettles are as follows : —

Shallow.

Size.	Diameter.	Depth.	Rim.
25 gallons.	29¼ inches.	10½ inches.	3½ inches.
30 "	31½ "	12½ "	3¾ "
40 "	33½ "	13 "	4 "
50 "	39 "	13½ "	4¼ "
60 "	42 "	15 "	4½ "
80 "	46¾ "	16 "	4⅝ "
100 "	49½ "	17 "	4⅝ "
125 "	53½ "	18½ "	5 "
150 "	56½ "	20 "	5½ "

Weigh about 5½ pounds to a gallon.

Deep.

Size.	Diameter.	Depth.	Rim.
20 gallons.	27 inches.	9½ inches.	1⅝ inches.
30 "	29 "	13¾ "	1¾ "
40 "	34 "	15 "	2½ "
50 "	36 "	13½ "	2⅝ "
60 "	41 "	17 "	2¾ "
80 "	42 "	18 "	2½ "
100 "	47 "	17½ "	3 "
120 "	49½ "	18¼ "	3 "

Weigh about 5 pounds to a gallon.

Extra Sizes.

Size.	Diameter.	Depth.
200 gallons	70 inches.	24 inches.
250 "	75 "	27 "
300 "	79 "	29½ "
350 "	81 "	30½ "
400 "	82½ "	31½ "
450 "	84 "	32⅝ "
500 "	85 "	33 "
550 "	86 "	34 "
600 "	87 "	35 "

Weigh about 7 pounds to a gallon.

The old mode of making brass kettles was by hammering upon a sheet of metal, until by degrees the required shape was assumed. The plan now in use is known as "Hayden's patent," December 15, 1851. Square blanks of sheet-brass are cut into circles of a diameter corresponding to the size of kettle required. After annealing, the metallic disks are brought in contact with cast-iron chucks revolving horizontally with great velocity. A small steel friction roller, resembling a button, is then brought in close contiguity to the metal, and, running along the outer surface of the blank, spins it out to the shape of the mold. Four such operations are commonly required before the kettle assumes its finished form, the metal requiring to be annealed after each. The course of the roller is marked by the concentric rings which are found upon most of the brass kettles in market. The processes of wiring, fixing on the ears and bales, are all required to make the kettle complete. Sizes range from ½ gallon to 32 gallons capacity.

Ket'tle-boil'er. An old form of steam-boiler whose lower portion was shaped as an inverted conical frustum, and the upper part a dome. The form resembles that of a tea-kettle.

Ket'tle-drum. The *kettle-drum* is so named from its resemblance to a hemispherical kettle. It is formed of thin copper, and has a head of parchment or vellum. Kettle-drums are used in pairs, slung on each side of the withers of a cavalry horse. One drum was tuned to the key-note and the other to the fifth of the key in which the piece in which they are to figure is written. The tuning is by a hoop and screws.

They are now usually supported upon tripod and used in orchestras. The *tam-tam* is the original kettle-drum, and has for its congeners the *darabookah* of Egypt, the *derbekkeh* of Syria. These are the lineal descendants of the Egyptian drum so commonly used in the festivities of the Pharaonic Egyptians. See DRUM.

This brass band or orchestral instrument is classed with those of *percussion*, in contradistinction to *stringed* and *wind* instruments. *Kettle-drums* are used in pairs, of which the larger is used for the lower sound.

Drumsticks are of three kinds : *wooden, wood covered with leather, sponge ends.*

Drums are also played *open* or *muffled.* The latter is by a piece of cloth covering the head and deadening the sound. See DRUM.

Ket'tle-fur'nace. (*Metallurgy.*) *a.* A basket-furnace or cresset in which lead or solder is melted for plumbing.

b. A furnace in which a kettle or kettles are set in a brick arch, as in sugar-boiling furnaces ; or above a box-furnace, as in agricultural boilers. See EVAPORATOR.

Ket'tle-stitch. (*Bookbinding.*) The stitch made in sewing at the head and tail of a book.

Kev'el. 1. (*Nautical.*) *a.* A large cleat for belaying. Sometimes formed by the ends of the top timbers which rise above the gunwale, or formed by timbers projecting at a small angle from the sides to belay large ropes, such as the sheets and tacks of the main-sail and fore-sail. See CLEAT.

b. A frame for spreading the main-sail.

c. An anchor-*palm.*

2. A stone-mason's hammer, used in spalling stone, and having a blade and point at the respective ends.

Kev'el-head. (*Nautical.*) The end of a top timber projecting above the gunwale and acting as a bitt or kevel, to belay large ropes, to fasten or *veer away* a warp, etc.

Key. 1. (*Machinery.*) *a*, a joggle-piece forming a lock or draw-pin in a joint. See HOOK-BUTT.

b, a wedge-piece of iron used for tightening the brasses of a bearing.

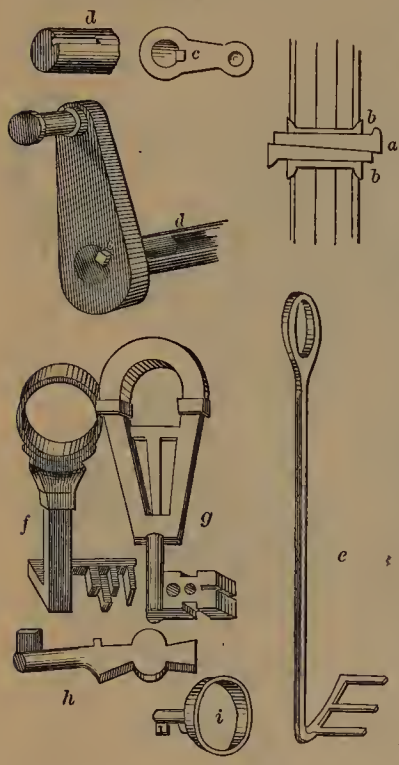
c, a fastening piece, such as a wedge or cotter in a chain. A *fore-lock.*

d, a piece *a* sometimes used in a mortise in connection with *gibs b*, in attaching a strap-head to a connecting rod.

e, a fin or wedge *c* fastening a crank on its shaft *d.* A long key on a shaft, which prevents the revolution of the wheel thereon, but permits longitudinal motion, is called a *spline.* See SPLINE ; FEATHER.

2. A spanner or wrench by which to turn a coupling-piece.

Fig. 2742.



Keys.

3. A portable instrument for shooting the bolt of a lock.

The locks of Egypt were sliding bolts, moving in keepers attached to the doors, and were probably moved from the outside by keys, somewhat similar to that shown in the illustration *c*, which is an ancient iron key brought from Egypt by Wilkinson. Ancient iron keys have been found at Thebes, and are preserved in the British Museum. They are from $1\frac{3}{4}$ inches to 5 inches long. See LOCK.

We read also in Judges iii. 23 – 25, that "Ehud went forth through the porch and shut the doors of the parlor upon him and locked them," and "his servants . . . . took a key, and opened them."

The modern key of Mosul, in the vicinity of what remains of the ancient Nineveh, is a long bar of wood, with two projections towards the end about a foot in length. As one traveler remarks, it is "well qualified, not only to open a door, but to knock down any one who might attempt to enter without permission."

The invention is ascribed by Pliny to Theodore of Samos, 730 B. C., but keys are mentioned in the siege of Troy, 1193 B. C. The bolt of the lock mentioned in the Odyssey was moved by pulling a latch-string which passed through the door and hung outside. Denon has engraved an Egyptian lock which no doubt had a key.

The Roman keys were very various (see *f g h i*, Fig. 2742), some like the old Egyptian and others like the modern. The *ring*, or *bow*, *stem*, and *bit* are all there. Some have hollow barrels, like our trunk keys. Thirty varieties are shown by Montfaucon.

The keys found at Herculaneum show that the art of lock-making (A. D. 79) was well understood.

4. (*Joinery.*) *a.* A piece of timber let transversely into the back of a board, which consists of several breadths, for the purpose of preventing warping.

b. The last board of a floor or platform which is driven into position and keys up the others.

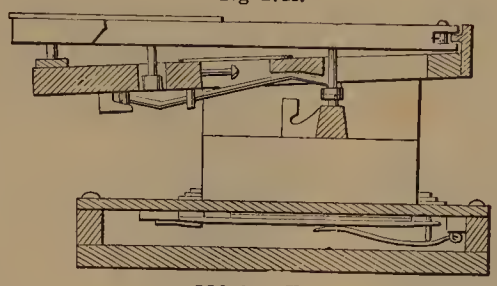
c. A tenon piece, of the nature of a dowel entering coincident parts in matched boards, and holding them together, or in correspondence.

d. The roughing on the under side of a veneer, which is made by a *toothing-plane*, and is designed to give the glue a better chance of adhering.

e. One of the wedge-shaped pieces or *striking-plates* beneath the ribs of a bridge *centering*, and by driving in which the *centering* is struck and the arch left self-sustained.

5. (*Music.*) *a.* One of a series of levers in a

Fig. 2743.



Melodeon-Key.

piano, organ, etc., which are operated by the fingers of the performer. (See PIANO MOVEMENT.) Keys are *manual* and *pedal*. *b.* The fundamental tone of a movement; or of an instrument, and to which its modulations are referred.

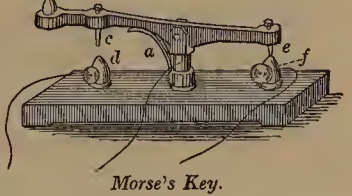
An illustration may be afforded by giving a comparative statement of the different keys of the *cornet-à-pistons*, the *trumpet*, and the *horn*.

	Cornet-à-Pistons.	Trumpet.	Horn.
1st,	C typical key.	A ♭	C high.
2d,	B ♮	G ♮	B ♮ "
3d,	B ♭	G ♭	B ♭ "
4th,	A	F	A ♮ "
5th,	A ♭	E ♮	A ♭
6th,	G	E ♭	G ♮
7th,	G ♭	D ♮	G ♭
8th,	F	D ♭	F
9th,	E ♮	C typical.	E ♮
10th,	E ♭	B ♮	E ♭
11th,	D	B ♭	D ♮
		A	D ♭
			C typical.
			B ♮
			B ♭
			C

See Berlioz's "Instrumentation and Orchestration."

6. (*Telegraphy.*) A device for breaking and closing electric circuits, so that the current may be interrupted to give signals.

Fig. 2744.



Morse's Key.

Morse's key for transmitting the currents by which the characters of his alphabet are indicated, consists of a pivoted lever provided with a spring *a*. When a message is being transmitted, the operator, by tapping on the button *b*, brings the points *c d* in contact, connecting the battery and line wire, and producing the combination of dots and dashes which form the Morse alphabet. When not in use for transmitting, the spring *a* keeps those points out of contact, and currents arriving by the line wire are conducted by the points *c f* to the indicator or to the relay.

7. A tooth-drawing instrument.

8. (*Masonry.*) The highest stone of an arch.

9. (*Plastering.*) That portion of the *rendering* or first coat of hair plaster which forces its way between the laths, and holds the body of the plaster in place.

10. (*Well-boring.*) A bent bar of iron spanning

the boring-rod just beneath a coupling, and serving to support the train of rods at the bore-mouth.

11. A term applied to instruments which are inserted and turned. See under the following heads:

Bedstead-key.	Key (*plastering*).
Bit-key.	Key-seat.
Box-key.	Key-screw.
Clicket.	Keystone.
Dental key.	Key-valve.
False-key.	Key-way.
Faucet-key.	Latch-key.
Foot-key.	Linch-pin.
Fore-lock key.	Master-key.
Fox-key.	Pass-key.
Key-bed.	Pick-lock.
Key-board.	Press-key.
Key-bugle.	Screw-key.
Key-fastener.	Skeleton-key.
Key-file.	Spanner.
Key-grooving machine.	Stepped key.
Key-hole guard.	Telegraph-key.
Key (*carpentry*).	Tuning-key.
Key (*lock*).	Turn-key.
Key (*machinery*).	Watch-key.
Key (*musical instrument*).	Wrench.

12. A *quay* or wharf.

Key-bed. The groove or seat of a key, which secures a wheel on its shaft.

Key-board. The finger-board of an organ, piano, or melodeon, on which the keys are exposed to view and touch.

Before the end of the sixteenth century, the present chromatic scale and key-board were introduced, the latter having the seven white and five black keys in each octave. The octave was divided into twelve equal parts about 1548.

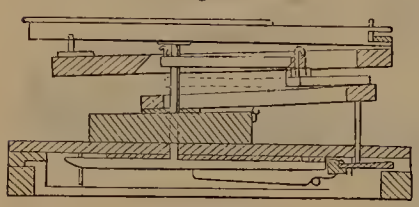
Key-bolt. One secured by a cotter or wedge instead of a thread and nut.

Key-bu'gle. (*Music.*) A brass wind-instrument with keys, seven usually. It will traverse chromatically a compass of more than two octaves, beginning from B♮ beneath the stave up to the C above the stave.

The bugle with pistons or with cylinders has a lower compass than the preceding.

Key-coup'ler. An attachment in a melodeon or parlor-organ to couple keys in octaves when desired. The coupling-levers cross each other, have their fulcrums at their rear ends, and are attached at their intersection. When the levers do not act, an additional pressure is put upon the valves.

Fig. 2745.



Key-Coupler.

Keyed Har-mon'i-ca. (*Music.*) An instrument in which plates of glass are struck by keys. The *glockenspeil* has bells struck by keys; a variation of the latter approaches the character of the keyed harmonica, having bars of steel for sounders.

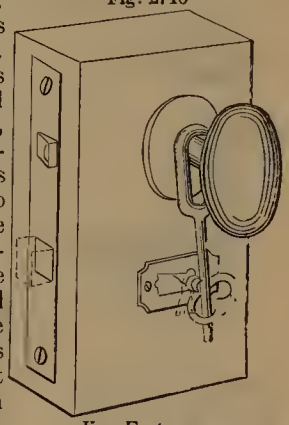
Key-fas'ten-er. An attachment to a lock to prevent the turning of the key by an outsider.

Key-file. A flat file having a constant thickness, and used in filing the ward-notches in keys.

Key-groov'ing Ma-chine'. (*Metal-working.*) One for slotting the center-holes of wheels to make a groove for the key, which fastens the wheel to its shaft, so that it may not turn thereon.

It is a modification of the planing-machine, which grew out of the slide-rest. It was invented by Roberts of Manchester, England. The wheel to be grooved is dogged to the sliding-bed and fed beneath the tool, which is reciprocated vertically above it by means of a crank or eccentric. To make the groove taper, the work is tipped to the required extent; to make several key-ways, the wheel is mounted on a turn-table with notches cut in its edges, to indicate the exact relative positions, as in planing squares, hexagons, etc. See Fig. 2748.

Fig. 2746



Key-Fastener.

The *slotting*-machine is an outgrowth of the *key-grooving* machine.

Key-guard. A shield which shuts down over a lock-key to prevent its being pushed out of the lock from the outside. In the example, a slotted escutcheon on the plate shuts over a flattened portion of the key-shank to prevent its being turned by an outsider. A pawl acts as a detent for the escutcheon.

Fig. 2747.

Key-Guard.

Key'hole-pro-tect'or. Mitchell and Lawton's English patent, 1815, has a revolving curtain for closing the keyhole.

Day and Newell's parautoptic lock has a revolving ring or curtain, which moves with the key and shuts the hole, so that wires and tools cannot be introduced alongside the key.

Mordan's keyhole protector (English), 1830, has a short pipe which, after the door has been locked, is thrust into the keyhole; attached to the pipe is a small lock so contrived that, on turning its key, two lancet-shaped pieces fly out laterally and bury themselves in the wood. The escutcheon cannot be removed until the small key has reacted upon the small lock; and until this removal has taken place, the large key cannot reach the keyhole.

Key'hole-saw. A long, thin saw. See COMPASS-SAW.

Key-mod'el. A mode of modeling vessels by shaping boards according to the horizontal lines, and laying them upon one another horizontally.

Key-pipe. The pipe of a lock in which a key is turned.

Key-screw. A lever, wrench, or spanner, for turning screws.

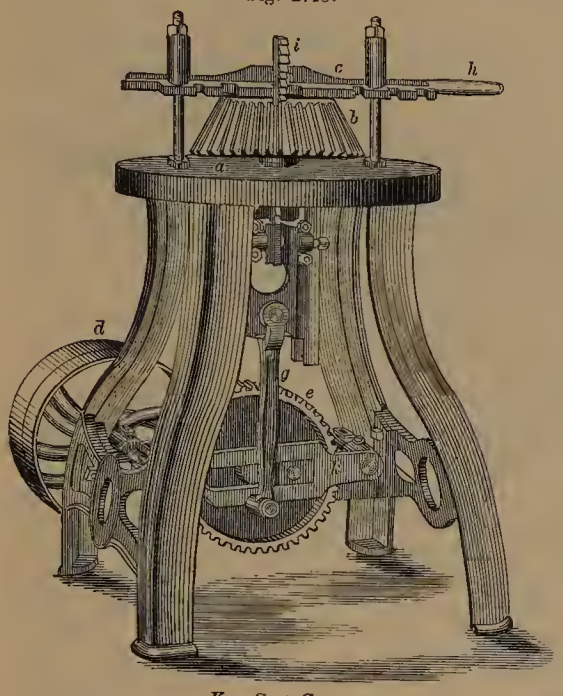
Key-seat. The groove in a wheel and shaft to receive the key which secures them together.

Key-seat Cut'ter. A machine for cutting grooves for keys in the center-holes of pulleys and gear-wheels. The wheel *b* is clamped by binder *c* and bolts to the table *a*. The cutter or saw *i* is reciprocated by wheel *e*, lever *k*, and pitman *g* below, driven by band applied to the pulley *d*. The saw is passed up to its work by means of the lever *h*, by the arrangement of the wrist-box sliding in the slotted lever *k*; a slow downward movement is attained, and a quick return, at which time the pressure on the lever *h* is slacked.

The machine for cutting key-seats has a horizontal plate for attachment to the table of a planing-machine, and the plate has a vertical portion, to which a wheel may be clutched. A mandrel, having a planing-tool, is secured by a jointed section to the head-stock of the planer, and is made to reciprocate within the eye of the wheel. The forward

end of the mandrel passes through a guide-ring, which has trunnions with bearing in a frame verti-

Fig. 2748.



Key-Seat Cutter

cally adjusted in the guide-standards by means of a screw.

Key'stone. 1. (*Masonry.*) The central voussoir at the vertex of an arch. The row or course of said stones along the crown of an arch is the *key-course.*

The length of the keystone, or the thickness of the archivolt at top, is $\frac{1}{15}$ or $\frac{1}{16}$ of the span.

2. In chromo-lithographic printing, the stone on which a general outline of the picture is drawn or photo-lithographed. Its object is to furnish a guide for the production of the work upon the several color-stones. Transfers from the keystones in common printing-inks, more properly called "offsets" to distinguish them from transfers from which impressions can be printed, are made upon as many stones as there are colors required. The outlines thus obtained are identical in form and size, and when, by means of the crayon or fluid litho-ink, — with subsequent etching, — certain portions of each are given the power of printing, the superimposition of impressions from all upon a single sheet of paper, each being printed with its proper color, will give the desired result in perfect register. The keystone may be one of those used in printing, but in the higher class of work it is an outline merely, used to aid the artists in the manner described.

Key-valve. (*Music.*) The pad or plug which closes an aperture in a wind-instrument. The valve being retracted the wind passes through, and the note is sounded. Valves are applied to the openings in the reed-board of a reed or organ, melodeon, accordeon, or concertina; on the faces of the keys of flutes, clarinets, flageolets, cornets, bugles, etc.

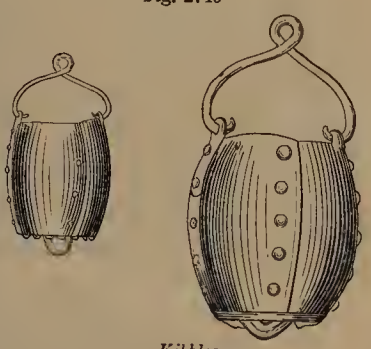
Key-way. A slot in the round hole of a wheel for the reception of the *key*, whereby the wheel is fastened to the shaft.

Kib'ble; kib'bal. (*Mining.*) A strong iron kettle with a bail, made of ¼-inch sheet-iron, riveted, and used as a bucket in raising ore from a mine. The term is used in copper-mining, and may have a Cornish origin.

Kib'bling-mill. A hand-mill of steel attached to a post, and used for crushing or grinding beans or other grain for feed. A *kibbling-machine.*

Ki-bit'ka. A Russian one-horse vehicle with two wheels. The kibitka is of various sizes, and may be either completely covered, entirely open, or provided with a hood behind. It has a single pair of long runners, and, to prevent upsetting, is provided with a guard-frame, which, starting from the body of the sleigh in front, spreads out some twelve or eighteen inches from the sides at the rear end. As soon as the vehicle tips, this framework touches the ground, and must break before the vehicle can capsize.

Fig. 2749



Kibbles.

Kick. (*Brickmaking.*) The piece of wood fastened to the upper side of a *stock-board* to make a depression in the lower face of the brick as molded.

Kid. A bundle of bushes or sticks planted on a beach to stop shingle or gather sand, to act as a *groyne.*

Kid'der-min-ster Car'pet. A carpet so called from being made somewhat extensively at a town of that name in England. The carpet is also known as Scotch, for a similar reason. Another of its names, *ingrain*, signifies that it is made of wool or worsted dyed *in the* grain; that is, before manufacture. Its names *two-ply* or *three-ply* indicate the number of webs which go to the making of the fabric.

It is composed of two webs, each consisting of a separate warped woof; the two are interwoven at intervals to produce the figure, one part being above and the other below. When different colors are used, the pattern will be the same on both sides, but the colors reversed.

Kid'dle. A weir or fish-trap.

Kid'ney-link. (*Harness.*) A coupling for the harness below the collar.

Kid'nip-pers. (*Molding.*) Nippers used in gun-molding for bringing the hoops taut around the mold.

Kil'las. (*Mining.*) The clay-slate in which the ores of copper and tin are found in Cornwall, England.

Kiln. A furnace for calcining; as plaster of paris or carbonate of lime in its shapes of marble, chalk, or limestone. See LIME-KILN.

Or for baking articles of clay in the biscuit condition. A *biscuit-kiln.* See GLAZE-KILN.

Or for drying malt, hops, lumber, grain, fruit, starch, biscuit, etc.

Or for vitrifying articles of clay, such as pottery, porcelain, bricks. See PORCELAIN; BRICK.

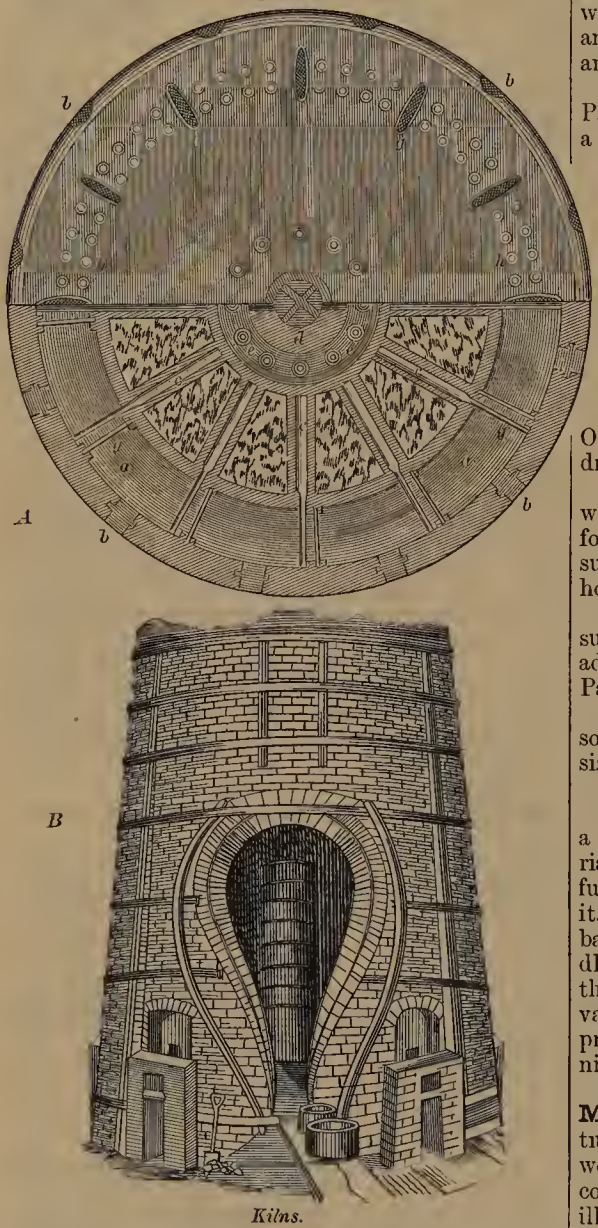
Herodotus speaks of baking bricks in kilns. The latter word may refer to a clamp, however. They certainly used kilns of some kind for their pottery, which was made of many kinds.

Hoffman's annular kiln (*A*, Fig. 2750), patented June 13, 1865, consists of a circular channel, *a a*, which receives the objects to be fired, introduced through doors, *b b*, in the outside wall. Flues, *c c c*, lead from the hearth of the kiln to the smoke-chamber, *c e e*, which surrounds the base of the chimney, *d*. The communication of each flue can be cut off at will, by means of a cast-iron, bell-shaped damper. An intercepting slide can be lowered in grooves, *g g*,

built into the walls of the kiln, immediatcly after each flue, so as to separate it at any distinct or equidistant compartment. The fuel passes through apertures *h h*, which are constructed in the arch, and falls through channels formed by the objects to be burned to a chamber in the hearth of the kiln, from which a certain number of small flues radiate to produce a free current from fire to fire.

The kiln has twelve compartments, to which there are twelve entries or doorways *b b*, also the same number of flues *c c c*, communicating with the smoke-

Fig. 2750.



Kilns.

chamber *c e*, and just as many openings *g g* in the arch for the reception of the large intercepting damper slide ; thus the kiln can be divided at any one of the twelve parts.

The apartments are used successively ; while one is being charged with bricks, tiles, or pottery, others are being burned, others are cooling, and one or more may be discharging.

The kiln-fire is supplied with warm air drawn through the apartments which are being cooled. The heat passing from the apartments where the fire is burning heats the one next in series to such an extent that the fuel introduced into the latter is ignited, and it commences burning on its own account.

Dampers in the flues connecting the apartments, and in the radial flues leading to the chimney stack, permit the caloric current to be turned as required.

An older form of pottery kiln for burning crockery is shown at *B*.

The piles of seggars are introduced through the large opening in front ; when the kiln is fully charged this is bricked up, and fires started in the furnaces surrounding the kiln. The heat is maintained until, in the judgment of the operator, the ware is sufficiently baked, when the fires are drawn, and when sufficiently cool the brick-work is removed and the seggars withdrawn.

A peculiar kiln is employed in the vicinity of Paris for burning plaster of paris. This substance, a sulphate of lime, frequently contains a proportion of the carbonate, as is the case in that obtained from the great quarry of Montmartre, near Paris, where it is employed instead of lime for making mortar.

The kiln is about ten feet long, and has walls at two sides and one end. Within, longitudinal walls are built up of the blocks of gypsum as they come from the quarry, the interspaces being filled with billets of wood. Over these, arches are built with the gypsum blocks, sufficiently stable not to fall in when the fuel is consumed. Over these are laid alternate layers of charcoal or dry wood to the depth of eighteen or twenty inches.

An aperture about six inches square in the end wall provides for draft. Fire is kindled in the flues formed at the other end, and maintained by farther supplies of small wood for from twenty-four to forty hours, until the calcination is complete.

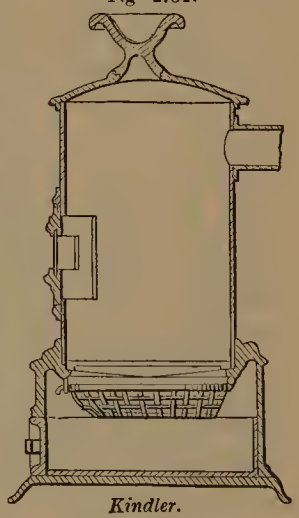
The cement made by combining the calcined gypsum with water and sand sets quickly, and is better adapted for stone, the common building material of Paris, than for brick.

Kin. A Chinese instrument having a body, a sounding-board, and five silken strings of different sizes.

Kin'cob. (*Fabric.*) An East-Indian laced satin.

Kin'dler. An attachment to a stove, by which a body of easily lit material is brought against the fuel in the stove to kindle it. In the example, the basket to contain kindlings is hinged beneath the grate, and when elevated in front is in a proper position for the ignition of the fire.

Fig 2751.

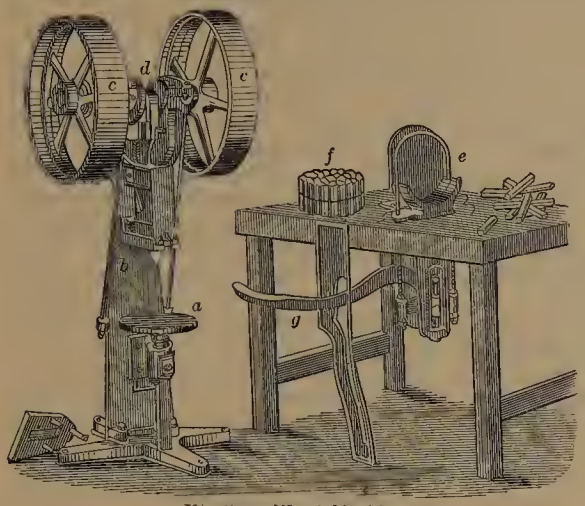


Kindler.

Kin'dling-wood Ma'chine. An apparatus for splitting the short wood used for kindling coal fires, etc. In that illustrated in Fig. 2753 the vertically reciprocating cutter is operated by a crank shaft rotated by pulley and belt connections, making about 125 strokes per minute ; the wood is placed on a circular table below the cutter, and the machine is adjusted to cut different lengths by varying the elevation of the table and by a clearing plate, shown detached to the left of the base of the machine. The bundling-machine is operated by a lever, which

works a toggle-joint, causing a loop to compress the bundle, placed in a semicircular rest, while being tied.

Fig. 2752



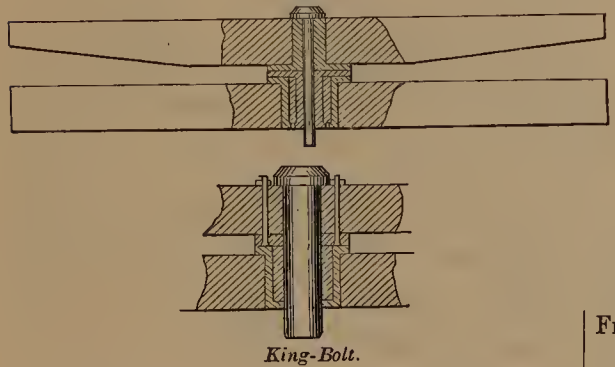
Kindling-Wood Machine.

In another bundling-machine, the split wood from the cutter falls into boxes on an endless belt, and is conveyed to the clamps into which the charges are dropped. These are closed by cam movement, a wire is passed around the bundle and automatically cut and twisted.

Still another machine has a cutting-edged cylinder, to which the bundles are delivered by a feed-wheel being forced through by a plunger and trimmed smooth.

Ki-ne'to-scope. An instrument invented by Perigal, for illustrating the result of the combination of circular movements of different radii in the production of curves. Also called *kinescope*.

Fig. 2753.



King-Bolt.

King-bolt. (*Vehicles.*) *a*. A vertical bolt which attaches the front of the body to the fore-carriage, and forms the axis of oscillation when the said carriage is turned sideways.

b. A similar part in a car, which forms the axis of revolution of the car upon the truck in turning curves. See CAR-TRUCK.

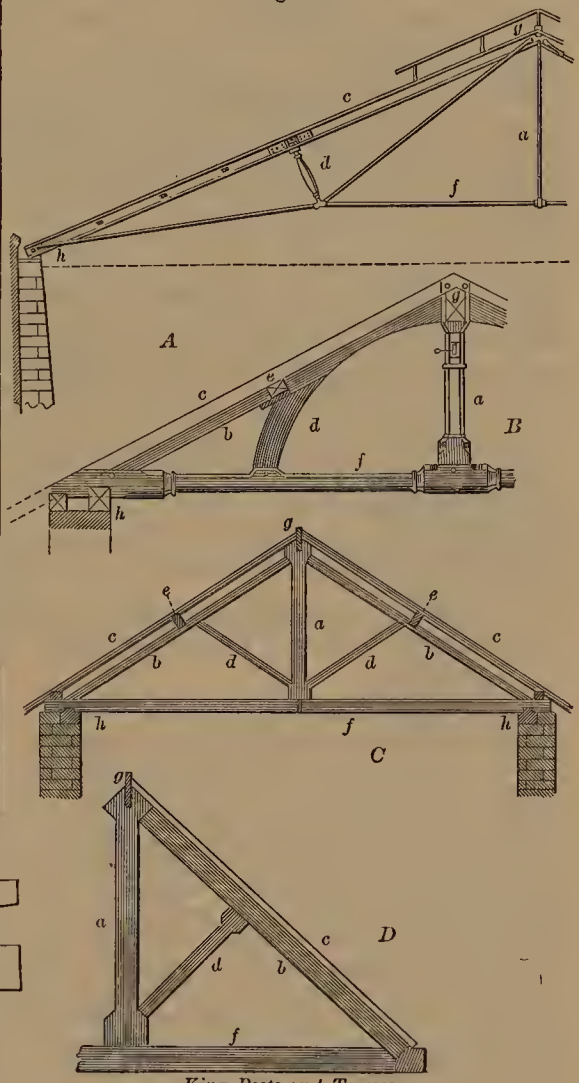
In the example, an elastic sleeve intervenes between the king-bolt and the metallic bushing, to absorb the jar.

King-post. (*Carpentry.*) A main post beneath the crown or ridge of a roof-frame.

Also known as *crown-post* or *joggle-post*. King-post trusses have several minor variations : —

a, king-post. (*King-rod* in the upper figure).
b, principal rafters.
c, rafter.
d, strut or purlin-post.
e, purlin.
f, spring-beam or tie-beam.
f, tie-rod (upper figure).
g, pole-plate.
h, wall-plate.

Fig. 2754.



King-Posts and Trusses.

A is a roof on the quay Jemappes, Paris.

B is from the roof of the church of Lagorce, France, twelfth century.

C is an ordinary barn-roof.

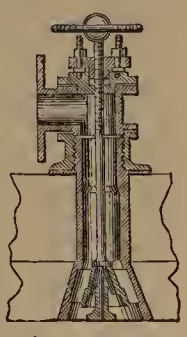
D a Gothic roof.

King-post Truss. See KING-POST.

King-post Roof. (*Carpentry.*) One having but one vertical post in each truss.

King-rod. A tension rod depending from the ridge of a roof and uniting with the tie-rod ; occupying the position of the king-post in wooden roofs. See KING-POST (*A*).

Fig. 2755.



Kingston's Valve.

King'ston's Valve. A conical valve, forming the outlet of the blow-off pipe of a marine engine ; it opens through the side of the vessel by turning a screw.

King-truss. A roof or bridge-truss framed with a KING-POST (which see).

Kink. (*Nautical.*) A sharp bend in a rope or cable which prevents its reeving through a block or a hole.

Kinsh. A crowbar used in quarrying.

Ki'o-tome. (*Surgical.*) A knife for cutting membrane; especially certain pseudo-membraneous bands in the rectum and bladder.

Kip. Leather of yearlings or small cattle. A grade between calf and cowhide. *Kip-skin.*

Kirb. See CURB.

Kish. (*Smelting.*) *a.* A carburet of iron which, when cold, appears in bright shining scales, but which is in the liquid form in the iron-smelting furnace, where, owing to its levity, it floats upon the surface. It possesses most of the properties of graphite, but contains less carbon.

b. The impurities which float on the surface of molten lead in a furnace.

Kit. 1. (*Photography.*) Also known as "inside frame." A thin, flat, rectangular frame of wood which fits within a plate-holder for the purpose of enabling the latter to carry a sensitized plate smaller than that for which it was originally designed. There may be many of these for one holder, and they often fit one within the other, forming a "nest." The inside corners, as is the case in the plate-holder itself, are provided with glass or hard rubber angle-pieces, upon which the plate rests to prevent contact between the wood and nitrate of silver solution adhering to the wet plate, which would cause stains upon the negative.

2. (Ger. *Kitt.*) A cement for stuffing canvas to place over the vents of carcasses to keep out the damp.

3. A small fiddle.

4. A large bottle.

5. A milk-pail or churn.

6. The tools of a workman or outfit of a tourist.

7. A flaring-bottomed tub for fish or butter.

Kite. 1. A light frame covered with paper or cloth, and flown at the end of a string.

Centuries of use among the Chinese, and the remarkable use by our Benjamin Franklin, have aided to make the kite respectable. Benjamin had a roughly made kite, two cross-sticks, over which was stretched a silk handkerchief, and this was flown in June, 1752. Franklin was not a boy at this time, but a mature man of 46. Betsy Trotwood observed, "Franklin used to fly a kite. He was a Quaker or something of that sort, if I am not mistaken, and a Quaker flying a kite is a much more ridiculous object than anybody else"; so he might have appeared to some of the Philadelphians. Some of his propositions for conducting and using the electric current seem strangely modern. He proposed to fire spirits, kill animals, drive machinery, and discharge guns. Some of these things he performed.

The kite has been used in scaling eminences; two remarkable occasions may be cited: the ascent of "Pompey's Pillar," a pillar of red granite 114 feet high, near Alexandria; and in the ascent of the Peter Botte Mountain in the Mauritius. It is also used for lodging a cord on steeples and other structures, to enable them to be fitted with lightning-rods or for the purpose of repair. The first wire of the foot Suspension-Bridge at Niagara was carried over by a kite.

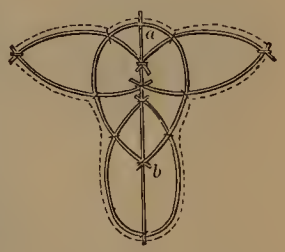
In 1827 Pocock yoked a pair of kites to a carriage, and traveled from London to Bristol. He determined that a 12-foot kite gave the power of a man, with a moderate breeze, and, when the wind is brisker, a power of 220 pounds. (This is an incomplete statement, but the figures are not ours.) The force, he states, in a rather high wind, is as the squares of the lengths of the kites; and two kites, of 12 and 15 feet respectively, will draw a carriage and four or five passengers at the rate of 20 miles per hour. (Grade not stated.) Pocock had an extra line to vary the angle of the surface of his kite, so as to adjust its tractile force, and side lines to vary the direction of the motion till it came nearly to a right angle with the course of the wind. His kites were made of varnished linen on jointed frames, so as to be folded and stored compactly.

The Indian and Chinese kites are made of Chinese paper, thin and tough, and the frames of finely split bamboo. They are gayly colored, and are sometimes made in the shape of dragons, — whatever that may be, — eagles, or spiders. The string is made of the silk obtained from a wild species of worm, and is called *nuck;* after spinning, it is treated with gum or glue, and then drawn through pounded glass. Being dried in the sun, it is ready for duty. This gritty coat is to enable it to saw asunder an adversary's line, should it become fouled, when flying on a wager or for sport. The Celestials put as much enthusiasm into the business as do the owners of trim wherries, fast nags, fleet greyhounds, rampant game-cocks, surly bull-dogs, dapper terriers, or the other thousand and one devices or excuses for actively wasting time.

Chinese kites are sometimes furnished with various æolian attachments which imitate the songs of birds or the voices of men. The pigeons also in Pekin are frequently provided with a very light kind of æolian harp, which is secured tightly to the two central feathers of their tails, so that in flying through the air the harps sound harmoniously.

The frame of the Japanese bird *kite* is made of thin bamboo, and is covered with colored paper. The wings, which are somewhat concave, and fall back a little, are dark maroon, and the body and tail represent a bird. Small white twine is used. By various devices, the hovering and soaring of a hawk can be admirably imitated. Length of middle cane 20 inches, spread of wings 26 inches; *a b*, points where the "belly-band" must be attached. Dotted lines show the paper.

Fig 2756.



Japanese Bird-Kite.

2. (*Nautical.*) One of the unusual sails above the royal; *sky-sails, moon-rakers,* etc.

Kit-ty-sol'. (Sp. *Quitasol.*) The Chinese paper parasol.

Klick'et; Klink'et. (*Fort.*) A gate in a palisade for the passage of a sallying party.

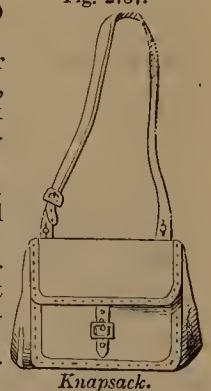
Kli-nom'e-ter. An instrument for measuring the angle of the dip of strata.

Knap'ing-ham'mer. (*Scotch.*) The stone-breaker's hammer.

Knap'sack. A soldier's or tourist's case or wrapper for clothes, etc., to be carried on the back during a march. See ACCOUTERMENT.

A tourist's or traveler's satchel. That shown has a pocket *A* and strap *B*.

Fig. 2757.



Knapsack.

Knead'ing-ma-chine'. A machine for incorporating dough. It usually consists of certain stirring-blades and stationary arms, and a spiral blade for discharging the homogeneous dough.

The *petrisseur*, or mechanical bread-maker, of Cavallier & Co., Paris, consists of a strong wooden trough, nearly square, with its two longest sides inclined. The bottom of the trough is semi-cylindri-

cal, and the ends support the axis of a cast-iron roller. A knife-edge is placed above the roller in a longitudinal position, and forms a practical division of the trough space into two semi-cylinders on the line of the axis of the roller. The roller being rotated, the dough is drawn between it and the bottom of the trough, which space is governed by lever adjustment. The knife-edge arrests it above; and when all has passed to one side the motion of the roller is reversed, when it is drawn back again. This is repeated until the materials are perfectly commingled and the quality uniform.

Another English *kneading-machine* has separate cells and heavy balls. A third has an agitator with a revolving axis and a series of rings angularly attached, and operating in a trough.

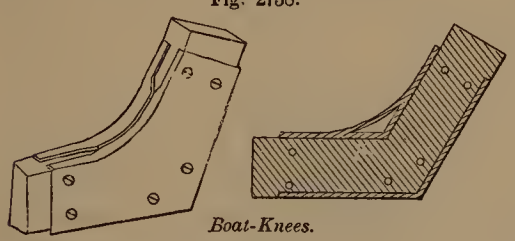
The *mixing-machine* of the ship-biscuit factory of the Victualing Department, Portsmouth, England, is a mixing-trough with a revolving axis furnished with two sets of knives, which mix 280 pounds of flour with 13 gallons of water in 2½ minutes. The *kneading-machine* is a cast-iron roller weighing 1,500 pounds, which rolls back and forth upon a bench, flattening out the slab of dough, which is again and again doubled and laid in the track of the roller. See BISCUIT-MACHINE.

Repeated passage between rollers, doubling the sliver between passages, is the ordinary mode of machine kneading. Harrison's biscuit-machine (English) operates thus (see BISCUIT-MACHINE), and so do the American CRACKER-MACHINES (which see). The hard-baked, unfermented cake called a *biscuit* by the French, English, and seafaring people generally, is a cracker among the landsmen of the United States, where it assumes many forms and is variously qualified as to ingredients, consistence, etc., *e. g.* sugar, water, butter, soda crackers.

Cracker-dough was formerly kneaded by an instrument called a *break*. It was a lever, pivoted at one end to a ring in the wall, and operating on a semicircular bench on which the dough was laid. The man who operated it was called a breakman, and brought his weight to bear on the lever, giving it and himself a dancing motion as the break traversed in its curved path, giving a succession of radiating impressions upon the slab of dough beneath it.

Knee. 1. (*Shipbuilding.*) A *compass-timber*. A naturally grown bent piece used to secure parts together, acting as a brace and tie. The *back* or outside bent portion is fayed to the parts to be united.

Fig. 2758.



Boat-Knees.

The exterior angle of a *knee* is the *breech;* the interior angle is the *elbow* or *throat*.

The *square* knee has a right angle.

The *knee without a square* has an obtuse angle.

The *knee within a square* has an acute angle.

The knee derives its specific name from its position, or the parts to which it is accessory, as, —

Cheek-knee; a compass timber at the head; also known as, —

Head-knee; a molded timber fayed edgeways to the cutwater and stem.

Hanging-knee; one fayed to the side, in a vertical position. The *knee up and down.*

Lodging or *deck-beam knees;* fayed to the side horizontally to secure the deck beams.

Dagger-knees, i. e. *diagonal knees;* fixed obliquely to avoid a port.

Standard-knee; one arm bolted to the deck, and the other against the ship's side.

The *carling-knee* is in the angle formed by the junction of a carling with a deck beam.

Heel-knee; a compass timber which connects the keel and stern-post.

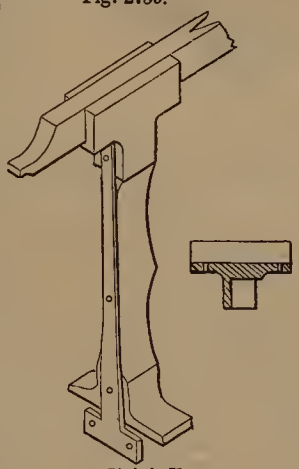
Transom-knee; helm-post knee, etc.

2. (*Carpentry.*) A piece of wood having a natural bend, or sawed to shape and fitting into an angle as a brace and strut.

3. An elbow piece which connects parts as that shown in Fig. 2759, in which the side plates are let into the pieces of timber and bolted thereto. The flanges lap around the edges.

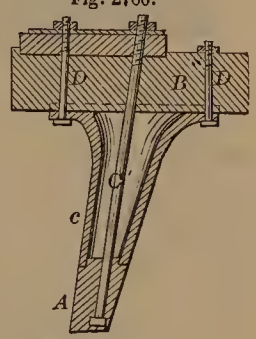
4. A piece framed into and connecting the bench and runner of sled or sleigh. It is usually mortised into the respective parts, but in the example the knee is sunk in the sockets of the metallic blocks.

Fig. 2759.



Sleigh-Knee.

Fig. 2760.



Metallic Knee.

Fig. 2760 shows a hollow metallic knee *c* secured by a straining-bolt *C* and screw-bolts *D* to the bench *B* and runner *A*.

5. An elbow or toggle-joint.

Knee-cap. (*Harness.*) A padded or leather cap secured by straps over the knees of racing, hunting, and other valuable horses when at exercise, to protect the part against abrasion in case of an accidental fall.

It is made of fabric, leather, caoutchouc, gutta-percha, compressed cork in a double pad, etc.

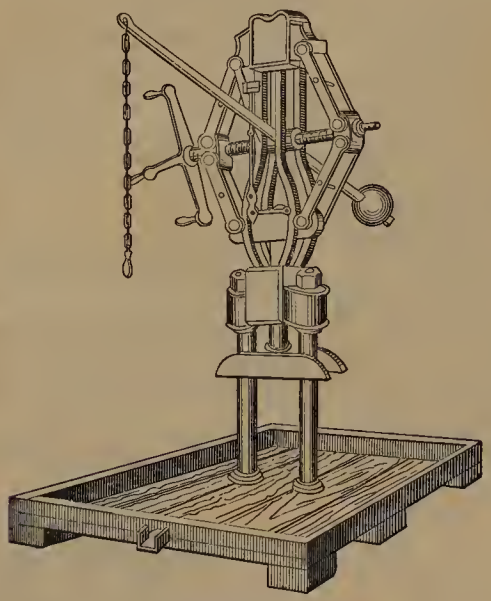
Knee-joint. A joint consisting of two pieces articulated endwise to each other, like the human knee. A *toggle-joint.* See TOGGLE.

Knee-joint Press. One in which power is applied by means of a double knee-joint articulated at the top to the upright framework, and at the bottom to a cross-head, from which proceeds the shaft which applies the force, and which works through a guide. At the junction of the branches the articulations are made with masses of metal forming screw-nuts, through which passes a horizontal screw, right-handed for one half its length, and left-handed for the other half. This screw is operated at first by means of a set of crank-handles at one end of it; and when the resistance becomes very great, by means of a counterpoised ratchet lever, which is shown in the middle of the frame. The force applied in this way is very great, since the operator can act on the lever with his whole weight.

Knee-stop. (*Music.*) A lever operated by the knee to work the swell of a cabinet organ.

Knee-swell. (*Music.*) An arrangement in an

Fig. 2761



Knee-Joint Press.

organ by which a greater or lesser amount of wind may be turned on to the reeds to vary the loudness of the tone.

Knife. 1. A cutting-implement having a blade sharpened on the edge, and distinguishable from a sword, a colter, and other things, by its form and uses.

The earliest forms of knives are made of flints (*a*, *b*, *e*, *f*, *g*, Fig. 2762), and after the introduction of bronze (*c*) they were still retained for the performance of religious observances. This is shown by the use of a "sharp stone" in performing the operation of circumcision, as recorded in Exodus iv. 25, where Zipporah operated upon her child in conformity to the Jewish law. Herodotus says that an Ethiopic stone was used for making the incision in the body of persons brought to be embalmed, in order to remove the intestines. Diodorus Siculus says that "it was not lawful to use metal." In the Berlin Museum are two flint knives (*a*, *b*) of ancient Egypt, which, no doubt, were used in their religious observances; for the embalming of bodies was of this character, and was under the control of the priests.

c is the knife as represented in the Egyptian hieroglyphics.

d shows an old Egyptian butcher with his dismembering-knife, and his steel stuck into his belt.

e f g are from Assyrian knives in the British Museum.

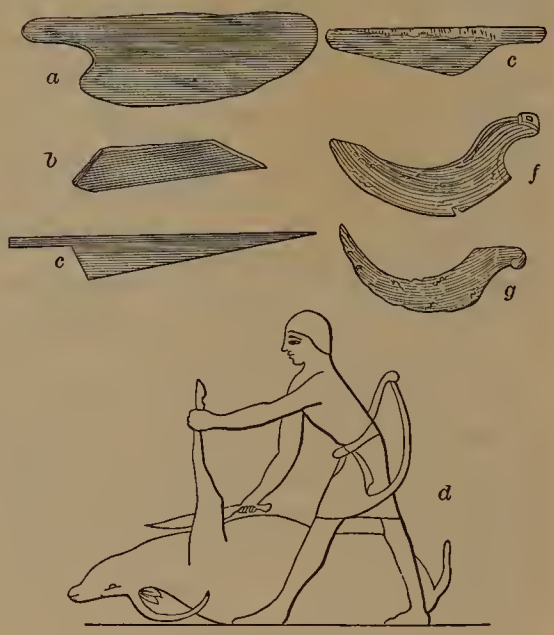
In the Egyptian museum of the late Dr. Abbott, New York City, are several of the Egyptian knives of Ethiopic stone. The operation of circumcision is now performed in Barbary with an ordinary pair of scissors.

The knives of ancient Egypt were usually of bronze, though blades of iron and steel were not unknown. Those of the latter metal have seldom, if ever, come down to our times, as they so readily rust and fall to pieces. They are, however, clearly distinguished from the bronze by being colored blue in the paintings of Bybau el Molouk, the bronze being red or brown. Blue swords (steel) are shown in the paintings of Thebes.

These old knives had tangs like our case-knives, and for the same purpose.

Among the first mentions of knives is that of Abraham, who took his knife to slay his son on Mt. Moriah. The history of edge-tools would include the history of the knife, and would carry one back to the Lacustrians and other remote inhabitants of the globe. History opens with men using knives of metal, but still retaining the flint knife for sacrificial occasions, as in Egypt, Mexico, and among the Hebrews. Other isolated races contented themselves with shells, as among the Caribs; Obsidian among the Peruvians, Mexicans; flint in ancient Europe and many other places. The first metallic knives were made of copper, and these were afterwards hardened by the addition of tin, making bronze. From the time of Osirtasen and Jacob down to the time of the Cæsars and Pliny, bronze maintained its ascendency, but eventually gave way to iron and steel.

Fig. 2762.



Ancient Knives.

The Mexicans had no iron tools; the material was bronze or obsidian, known by them as *itztli*. Of this they made knives, razors, and serrated swords.

The knife of the Tahitians, previous to the advent of Europeans, was splinter of bamboo. All the tools of the islanders were of bone, wood, shell, or stone. Metal was unknown, and iron was at first supposed to be a very hard wood. The first nails they received were planted in the gardens, in the hope that they might sprout.

The pruning-knives of the Feejees, when first discovered, were of tortoise-shell on wooden backs. Their hoes were a bone from the back of a turtle, a plate of tortoise-shell, or an oyster-shell. With their tortoise-shell knives they dexterously cut up their *bakolo* (long pig), as they call a baked human carcass, to distinguish it from short pig, the swine, whose meat it is said to resemble.

Whittling is not a modern or merely American pastime: —

> "A Shefeld thwitel bare he in his hose."
>
> CHAUCER.

Stow says that one Matthews on the Fleet Bridge was the first in England who made fine knives, and that he obtained an act, 1563, against the importation of foreign ones.

Clasp or spring knives came to England from Flanders, and were common in 1650.

In the manufacture of pocket-knives, a bar of

steel destined to furnish a number of blades is heated to redness. A length is cut off, and the forger speedily *moods* this, that is, shapes it roughly into the form of a pocket-knife blade. Another heating is then required to fit the end for being fashioned into the tang, and another before the operation of *smithing*, the last stage of which is the stamping of the mark of the thumb-nail to facilitate opening. The tang is then ground and the blade marked with the name of the firm. The slight bulge on the reverse side caused by this operation is removed by fire or the grindstone. The blade is then hardened by heating it to redness and then plunging it into water up to the tang. Then follows the tempering to a light straw color. After this the various kinds of blades undergo sundry grinding operations to fit them for being hafted. Twelve distinct processes have by this time been gone through, and many more are necessary before the knife is completely finished, although the number of hands which it has yet to pass through depends in a great measure on the finish to be given to the handle, and the quality of the blade.

For varieties of knives, see under the following heads: —

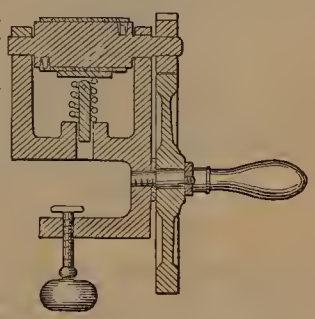
Amasette.
Amputating-knife.
Arteryotome.
Balance-knife.
Bark-knife.
Beam-knife.
Bill.
Bistoury.
Board-cutting knife.
Bowie-knife.
Bread-knife.
Bronchotome.
Budding-knife.
Butcher-knife.
Butteris.
Butter-knife.
Cane-knife.
Cane-stripping knife.
Can-opening knife.
Canvas-cutter.
Carving-knife.
Case-knife.
Cataract-knife.
Catling.
Catty.
Cephalotome.
Cheese-knife.
Chondrotome.
Chopping-knife.
Cionotome.
Cirsotome.
Clasp-knife.
Cleaver.
Cleaving-knife.
Clipper.
Coreotome.
Cork-cutter's knife.
Corn-knife.
Corn-stripping knife.
Costotome.
Cradle-scythe.
Craniotome.
Cream-slice.
Currier's knife.
Cutlery.
Cystitome.
Cystotome.
Desk-knife.
Dirk-knife.
Dissecting-knife.
Doffing-knife.
Double-knife.
Drawing-knife.
Edge-tools.
Entereotome.
Erasing-knife.
Fish-knife.
Fleshing-knife.
Flint-knife.
Floor-cloth knife.
Folder.
Fruit-knife.
Gardener's knife.
Glazier's knife.
Grafting-knife.
Grainer.
Hack.
Hacking-out knife.
Half-moon knife.
Ham-knife.
Hay-knife.
Heading.
Hoof-paring knife.
Howel.
Hysterotome.
Jack-knife.
Jigger.
Keratome.
Kiotome.
Knife-cleaner
Knife-edge.
Knife-file.
Knife-polisher.
Knife-rest.
Knife-sharpener.
Lancet.
Leather-knife.
Ledger-blade.
Machete.
Meat-knife.
Meatus-knife.
Metrotome.
Microtome.
Mincing-knife.
Moon-knife.
Neurotome.
Opening-knife.
Oyster-knife.
Palette-knife.
Paper-knife.
Parallel-knife.
Paring-knife.
Pen-knife.
Pharyngotome.
Plow-knife.
Pocket-knife.
Pruning-knife.
Putty-knife.
Race-knife.
Raising-knife.
Razor.
Rhinoplastic knife.
Round knife.
Rubber-knife.
Saddler's-knife.
Scalpel.
Scythe.
Serpette.
Shave.
Shoe-knife.
Slicker.
Sorghum-knife.
Spatula.
Splitting-knife.
Sportsman's-knife.
Spring-blade knife.
Steel.
Stopping-knife.
Striking-knife.
Stripping-knife.
Swing-knife.
Synosteotome.
Syringotome.
Table-knife.
Tenotomy-knife.
Tobacco-knife.
Trachitome.
Tonsilitome.
Trimmer.
Unhairing-knife.
Urethratome.
Uterotome.
Valentin's knife.
Welt-knife.

2. A blade in a machine, as in a *straw-cutter*, *rag-engine*, and what not.

Knife-board. (*Domestic.*) One with powdered bath-brick to clean knives upon.

Knife-cleaner. (*Domestic.*) An implement for cleaning knives. In the example, the frame is clamped by a set screw to a bench or table, and the cylinder is rotated by driving wheel and pinion; the guard holds a supply of polishing material, and the knife lies on a block which is pressed by a spring against the cylinder.

Fig. 2763.

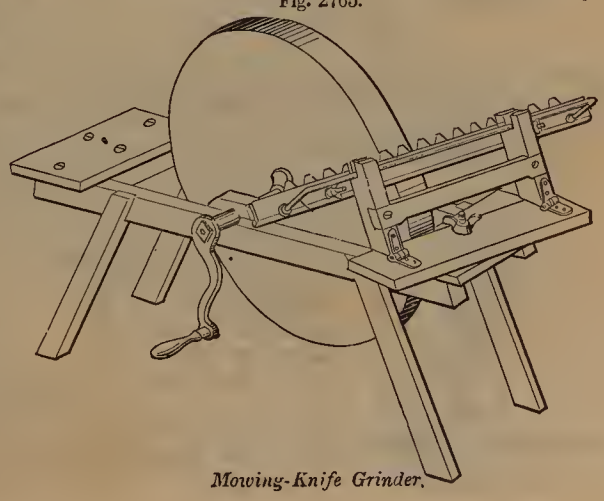


Knife-Cleaner.

Knife-edge. A sharpened steel edge resting against a horizontal surface, the two serving as a means of suspending a scale beam, or the scales from the beam, of a delicate balance, so as to obviate friction as much as possible.

Knife-file. A file with a very acute edge, the cross-section being an isosceles triangle with a short base. Known also as a *feather-edge* file. It is used

Fig. 2765.



Mowing-Knife Grinder.

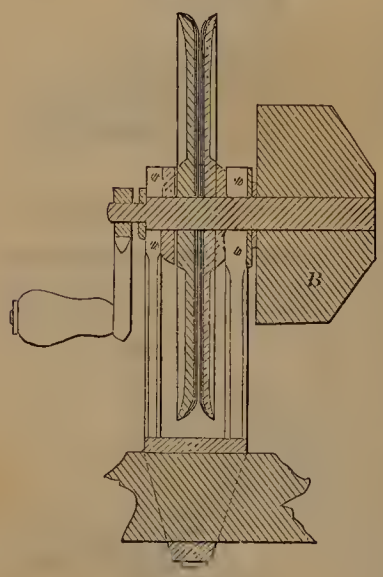
in cutting narrow notches, and in making an entering kerf for saws and for files with broader edges. Also in beveling or chamfering the sides of narrow grooves.

Knife-grind'er. 1. A grindstone or emery-wheel for grinding knives. See GRINDSTONE; EMERY-WHEEL; TANITE; LAP; GLAZER, etc. See list under GRINDING AND POLISHING.

2. A machine for special service, as in the example, which is a stone for grinding the knives of mowers and reapers. It has a holder set at such an angle with the frame, and also at such an inclination as to present the triangular knife-sections to the grinding face of the stone.

Knife-pol'ish-er. (*Domestic.*) A machine for cleaning the rust and stain from table-knives. In the example the knife-blade is slipped between a pair of disks, which are revolved by the crank. The disks are covered with a felted fabric, composed of linen and wool. The fabric is made by enclosing a linen bat between two bats of wool in the process of felting.

Fig. 2765.



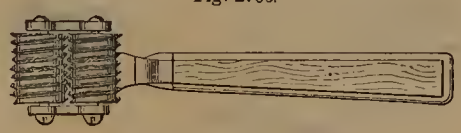
Knife-Polisher.

B is a bevel-faced grindstone for sharpening knives.

Knife-rest. A little pillow of metal or glass to rest the blade of a knife upon, at table. *Balance-handle* knives have rendered it unnecessary except with *carvers*.

Knife-sharp'en-er. (*Domestic.*) *a.* A steel. *b.* An implement for sharpening table-knives by drawing them between two steel edges. In Fig. 2766 it consists of two screw-threaded rolls set in a frame, secured in a handle, and between which the knife is to be drawn.

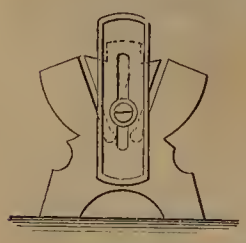
Fig. 2766.



Knife-Sharpener.

In Fig. 2767, there are two inclined jaws with a plate which crosses them obliquely. The middle plate is adjustable between the oblique side slots, and forms one side of each cutting jaw.

Fig. 2767.



Knife-Sharpener.

Knife-tool. A graver shaped like a knife.

Knight. (*Nautical.*) A wooden block with a sheave abaft the fore or the main masts, and known respectively as the *fore*-knight and *main*-knight.

Knight'head. (*Shipbuilding.*) One of the first *cant*-timbers on each side of the stem, which rise obliquely from the keel and pass on each side of the bowsprit, to secure its inner end.

Knit'ting-burr. A wheel having wings arranged radially and diagonally across its face, and adapted to operate upon the yarn and the fabric. There are several kinds, as follows: —

A *loop* wheel, whose wings are notched, and which take the yarn delivered by the guide, and push it up under the hooks or beards of the needles. A *sinker* wheel, which presses the yarn into loops between the needles, to insure that there shall be enough to form the proper-sized stitch in the fabric. A *landing* heel, which raises the loops of the fabric a short distance above the points of the needle-beards while they are closed by the *presser*. And a *stripping* or *knocking-over* wheel, which throws the loops of the fabric entirely over the tops of the needles to complete the stitch. See KNITTING-MACHINE.

Knit'ting-gage. The number of loops contained in three inches of breadth.

Knit'ting-ma-chine'. The art of knitting is modern; it cannot be traced back farther than about A. D. 1500, and is believed to have originated in Scotland shortly previous to that date. It consists in the construction of a looped fabric in which for the first row a succession of loops are *cast on* or preferably *knitted on* to a needle, and in succeeding rows each loop is passed through the loop of each succeeding row. It differs distinctly from *braiding*, *netting*, and *weaving*, which is, perhaps, the order of invention; *knitting* being scores of centuries later than either of the others.

Braiding is synonymous with *plaiting*, and is found among the most barbarous nations; none so ignorant that they cannot plait strips of hide or of bark, or braid a number of vines together to make a band. This is one degree of advance upon what nature provides them ready made, a rope of twisted tendrils or vines which, in reaching after a support, have mutually embraced and climbed upward. The natives of Tahiti, when discovered by Cook, were very skillful in making mats, which were plaited so as to resemble a woven fabric, and in other countries such are farther embellished by tufts. The process of making, however, was not by *warp* and *weft*, — was not *weaving*, — but was by braiding or plaiting a given number of strands arranged on two sides of a square, like the crosses we used to make of strips of differently colored papers when at school.

Netting is quite another matter, and is a fabric whose meshes are made over a mesh-stick and knotted at the intersections; as Dr. Samuel Johnson learnedly defines: "Network. Anything reticulated or decussated at equal distances, with interstices between the intersections."

The width of the mesh-stick determines the size of the meshes, which are knotted upon it. References to netting are frequent in the Hebrew chronicles, the Book of Job, the Prophets, in Homer, Virgil, and elsewhere. Oppian distinguishes many kinds. They are frequently shown in the Egyptian tombs and temples. See NET.

Weaving involves a machine, though this is sometimes of an extremely simple kind. It involves a beam or a means of stretching out the yarns into a flat row; also some means of dividing the yarns into a series above and one below, the space between being the *shed* into which the weft is laid; the upper and lower sets of yarns, changing places, lock the weft, and form another shed for a second weft thread, and so on. See LOOM; also, for list of parts and appliances, see WEAVING.

Knitting consists in making a fabric by enchaining a single thread. It is thought to have originated in Scotland about A. D. 1500. It was in use for superior articles of hose in England and France in the first half of the sixteenth century. Knitted silk stockings were worn by Henry II. of France, 1547, and by Queen Elizabeth in 1560. About this time knitted worsted stockings were made by William Rider of London, after the pattern of some imported from Mantua. Silk and worsted stockings were imported from Spain and Italy into England during the reign of Henry VIII. Spain was always famous for its sheep and wool. (See MERINO.) In 1530 the word *knit* was common in England, and occurs in Palgrave's grammar. In 1577 the country folks knitted their own stockings.

In 1589, William Lee, M. A., of Cambridge, England, invented and made a model of a knitting-frame. He applied to Elizabeth for help, and then to Henry IV. of France, who promised it. The assassination of Henry threw him into poverty and obscurity, in which he died. His workmen, with their stocking-frames, settled in Derbyshire and started a factory, which soon threw the hose of woolen cloth and leather entirely out of the market. Queen Elizabeth refused a patent to William Lee on account of the value of his invention; as it would interfere with the employment of a great number of her subjects, and to make the stockings for a whole people was too large a grant for any individual. About the same style of remark as was urged by Jefferson against one of Oliver Evans's patents, the "hopper-boy," so called.

Cotton stockings were first made by hand about 1730. The Derby ribbed stockings were patented by Jeremiah Strutt, in 1759.

The knotter frame patented by Horton, 1776.

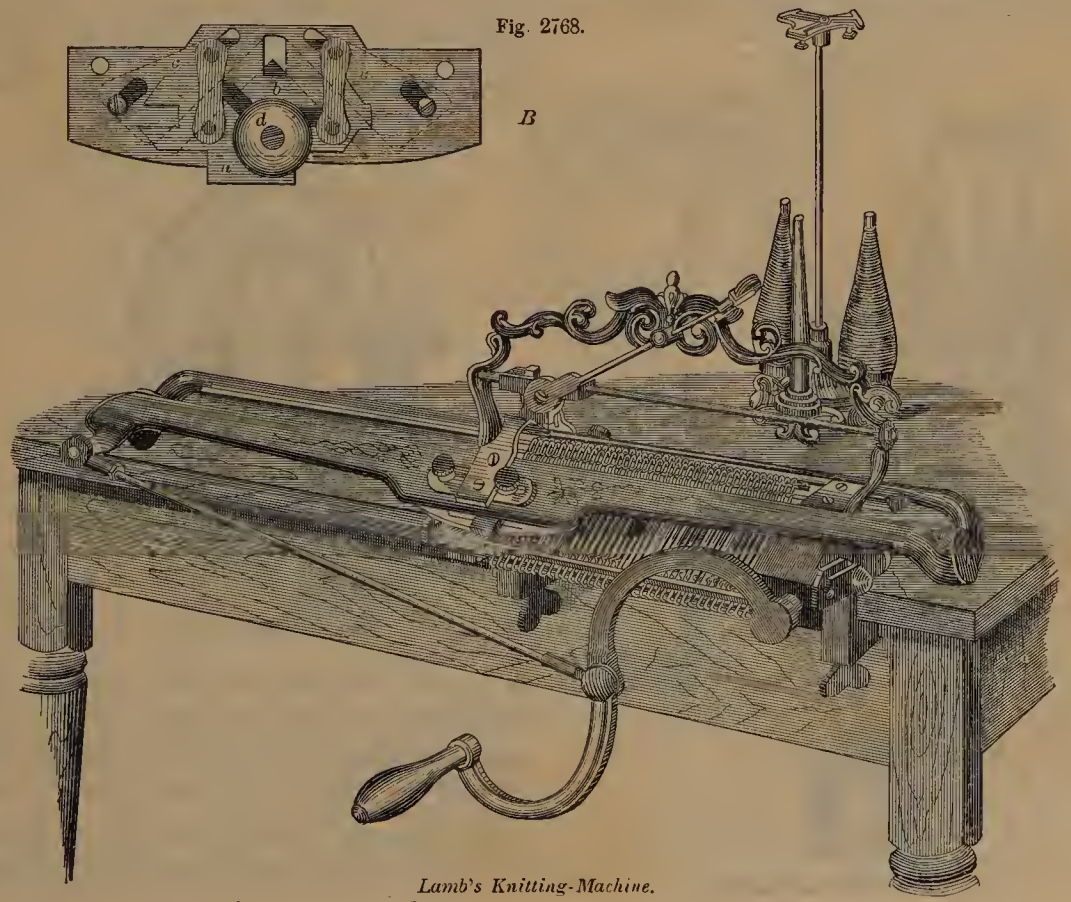
Of a Chinese village called "the old Duck," the Abbé Huc writes: "What struck us most in this place was that the art of knitting, which we had imagined unknown in China, was here carried on very busily; and, moreover, not by women, but by men. Their work appeared to be very clumsy; the stockings they made were like sacks; and their gloves had no separation for the fingers. It looked very odd, too, to see moustachioed fellows sitting before their doors spinning, knitting, and gossiping like so many old women."— *Travels in Tartary.*

Lamb's knitting-machine (Fig. 2678) is given as an example of that class which employs straight rows of needles in contradistinction to the machines using a circular system of needles, and to the single-needle machine. In the Lamb machine, a tubular web is produced by the operation of two straight parallel rows of needles, widening and narrowing being accomplished by increasing or diminishing the number of needles in action.

The frame is attached by thumb-screws to the edge of a table, and has its two upper sides inclined towards each other, their upper edges being separated far enough to allow the fabric produced to pass down between them. Supported by the needle-bed is a carriage, reciprocated by means of a crank. Through the arch that passes over the top of the machine is a horizontal rod upon which moves a slide that carries the guide for delivering the yarn into the hooks of the needles. Parallel grooves or channels are cut across the bed in which the needles are placed. In these grooves the needles can be moved their entire length, and can thus be brought into operation for widening, or thrown out of operation for narrowing, without removing them from the machine.

The needles employed are self-knitting, being constructed in such a manner that when fed by the yarn and carried an inch forward and back they form the loops by their own action. The lower ends of the

Fig. 2768.



Lamb's Knitting-Machine.

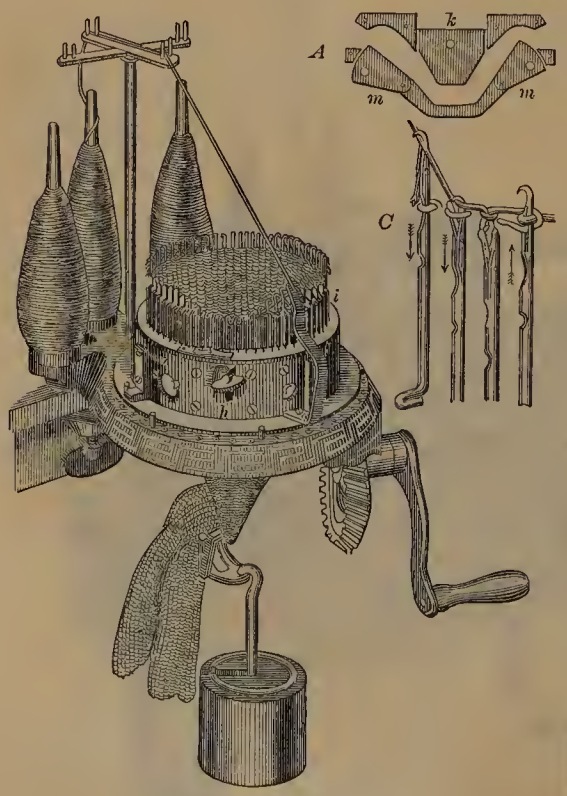
needles have an upright shank, extending above the face of the needle-bed, and are operated upon by cams that are attached underneath the center of the carriage in such a manner as to move the needles forward and back. There are two sets of these cams, one for each row of needles.

B is a representation of one of the sets of cams, which consists of the plate *a*, the two wing-cams *c c*, and the V-shaped cam *b*, which is held in place by the screws that pass through the washer *d*, in the diagonal slot of the plate *a*. As the carriage to which these cams are attached is drawn back and forth over the needle-bed by the crank, the needles are carried up on one side of the V-shaped cam in the groove or space between that and the wing-cams, the yarn-guide at the same time delivering the yarn into the hooks of the needles, which are then drawn down by the wing-cam on the other side of the V-cam, thus forming the loops.

The slide *a* is made to shift by its lower projection coming in contact with adjustable cam-stops, that are placed at the ends of the needle-bed. When the plate comes in contact with the right-hand cam-stop, the screw through the washer *d* is forced up the diagonal slot, and brings up the V-shaped cam, thus closing the space between it and the wing-cams. When closed, the needles pass below the cam without operating. By the adjustment of the cam-stops either or both of the cams may be left open or closed at the same time, so as to operate the two rows of needles separately, alternately, or together; thus forming three entirely distinct webs, — tubular web, plain flat web, and ribbed flat web.

As any number of needles can be moved up at the start, or be moved up or down at either end of the rows of needles at any time, so any size of web can be set up and any number of loops can be added to or taken from it at will. By thus knitting the fabric, either tubular or flat, plain or ribbed, in any desired shape, a great variety of staple and fancy-knit goods may be produced.

Fig 2769.



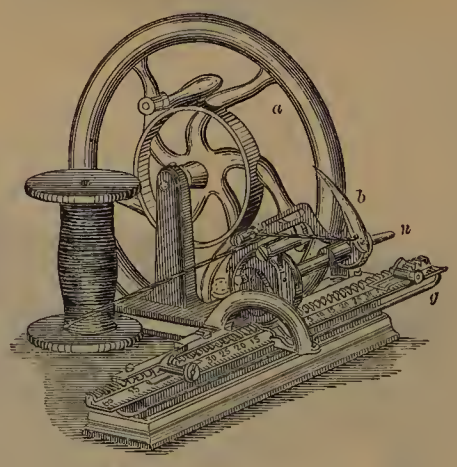
Bickford Knitting-Machine.

The loops are formed on precisely the same principle as in hand-knitting.

The Bickford knitting-machine (Fig. 2769) is a specimen of the circular system. A bed-plate having a vertically projecting and grooved needle-guiding cylinder or bed *i* is secured to a table or suitable support. On the bed-plate is a loose ring, provided with a thread-guide for conducting the thread to the needles, and about the needle-cylinder is a revolving cylinder *h* having an annular groove interrupted by a cam portion (see *A*) and provided with adjustable cams *k m*, which govern the downward motion of the needles, and consequently the length of the loops, and raise the needles; and two of these latter cams are needed to provide for reversing the machine for knitting the heel or a flat web. The cam-cylinder is moved by a bevel gear connected to a driving-crank, and when moved continuously in one direction knits a circular web; and this web may be narrowed as desired to fashion the leg by removing needles, and placing their loops on adjacent needles. The needle on the left, at *C*, is receiving the thread within its hook, and it is subsequently moved by the cam-cylinder into the positions shown to form the thread so taken into a loop. When the heel is to be formed, a portion of the needles are drawn up, thus retaining their loops, and the number of needles left in action correspond with the width of the heel to be formed. The cam-cylinder is now to be reciprocated in opposite directions, and in order to keep the thread-guide in advance of the descending needles sufficiently far, so that the thread will be caught, pins are inserted in the bed-plate, and engage the heel of the thread-carrier, and stop it just before the cam-cylinder is stopped.

Fig. 2770 is an example of what is known as the single-needle machine. The loops are formed and held on the teeth of a comb, which is moved along, one tooth at a time, by means of a rack on its rear side, whose teeth are engaged by a fin on a wheel *c*

Fig. 2770.



Hinckley's Knitting-Machine.

on one end of a shaft *n*, that is driven by the main wheel *a*, one part of the fin being movable, so that it can be swung from side to side, to vary the direction of the motion of the comb by a tri-armed lever located in the wheel *c*, and which strikes one or the other of the movable stops *g*.

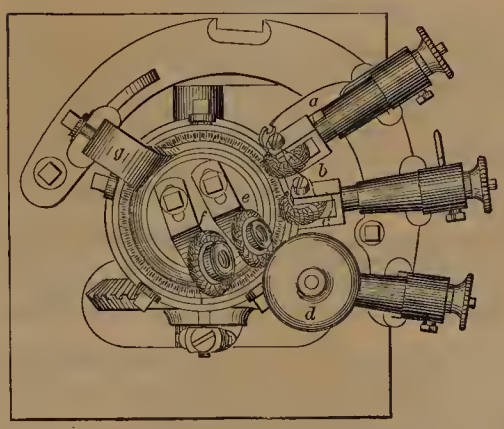
A single needle *b*, carrying the yarn, and a looper, are used, the former being shown in the cut as thrown up out of operation, for the purpose of being threaded.

When in operation, it reciprocates in an arc under the comb, the slot in its actuating arm engaging a crank-pin on the side of the wheel *c*. The looper reciprocates in an arc above the comb, a pin in its actuating arm projecting into a groove in the side of the wheel.

The needle and looper being in their rearmost position, and there being a loop on each tooth of the comb, the needle advances under the comb and through one of the loops, which it removes from the comb and holds a while. The looper then advances above the comb, and its point enters between the yarn and the side of the needle. The needle then recedes, leaving its yarn in the form of a loop on the looper, and dropping the old loop, and the looper also receding, deposits its loop on a tooth of the comb, the latter being then moved forward one tooth for the formation of the next loop in the same manner.

Fig. 2771 is a machine of the ordinary circular kind, and produces a plain tube. The needles are bearded and fixed around the periphery of a rotating cylinder. They have no endway motion, but the stitch is formed as follows, it being assumed that there is already a row of them upon the needles and near their lower ends. The yarn delivered through the eye in the end of the guide *a* is taken and

Fig. 2771.

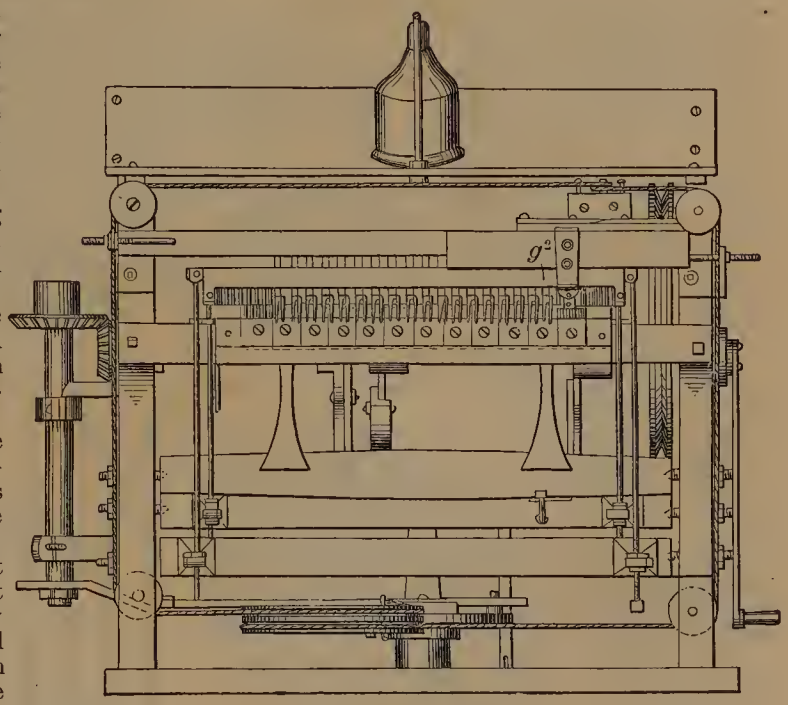


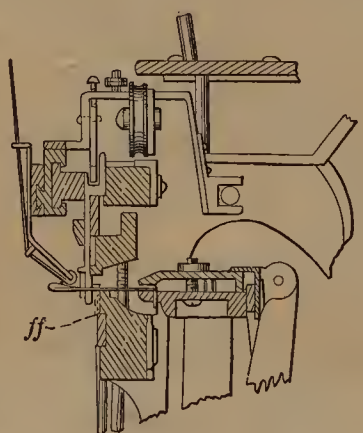
Circular Knitting-Machine.

B, Fig. 2771, shows a piece of ordinary knitted goods with loops distended.

Fig. 2772 is a machine of the kind which produces a plain, flat strip of fabric; it is an ordinary straight machine, and operates as follows: —

Fig. 2772.





Flat-Web Knitting-Machine.

pushed by the notched wings on the *loop-wheel b* up under the beards of the needles. The wings of the next or *sinker wheel c* then press the yarn in between the needles to insure that there shall be a sufficient quantity to form the proper-sized loops. The needle-beards are then pressed in, so that their points enter a depression in the stems, by the *presser-wheel d*, the yarn being thus inclosed between the beard and the stem, the old loops being at the same time raised, by the *landing-wheel e*, a short distance above and outside of the points of the beards. The *stripping* or *knocking-over* wheel *f* then throws the old loops entirely over the tops of the needles, and the fabric, with the newly formed row of loops, is pressed down to the lower ends of the needles by the curved cloth-presser *g*.

The meshes being in their extreme forward position, and the last-formed row of stitches being near their rear ends, the guide g^2 moves along the front of the machine, laying the yarn on the stems of the needles. The sinkers *c* are at the same time depressed, one after another, by the cam or *slur* above them, and depress the yarn into loops between the needles, which latter are then drawn slightly backward so that the yarn may pass under their beards. The presser-bar then descends upon and closes the beards, which then enter the old loops of the fabric, and the sinkers are raised in a body by the lifting bar in their rear (shown below in the sectional view). The needles receding to their extreme backward position, the old loops are thrown over their heads by being drawn against the plates *f f*. As

the needles move forward, the sinkers are all depressed in a body in front of the fabric, by the bar in front of the sinkers, to keep the loops back on the needle-stems. The needles then move entirely forward, and the looping operations are repeated.

The following are the technical names of the parts employed in knitting-machines : —

Beard ; a long flexible hook on the upper end of the needle, and over and under which the yarn is moved to form the loop or stitch.

Dividing (or *bar*) *sinkers ;* sinkers placed intermediate of the *jack-sinkers*, and which, after the jack-sinkers have operated, descend in a body to divide the yarn into proper-sized loops between the needles.

Fashioning-needle ; one of a series, placed at each or either end of the row of needles, which are brought into or thrown out of operation to *fashion*, that is, widen or narrow the fabric.

Jack ; a lever connected directly to and operating the sinkers.

Knocking-over bar ; the bar against which the loops and fabric are drawn as the needles retreat, so that the loops shall be thrown or knocked over the heads of the needles.

Latch ; a pivoted piece on the shank of a needle, and which swings forward to cover the hook and allow a loop to pass over its head, or back to uncover the hook, so that it may receive yarn to form a new loop.

Latch-opener ; a device operating between the latch and the hook of the needle to throw back a closed latch, so that the yarn shall be surely laid under the hook.

Lead ; a block of lead cast around and holding the shanks of two or more needles.

Point-shifter, or *tickler ;* a pointed instrument which takes a loop from one needle and transfers it to another for narrowing the fabric.

Presser ; a device which closes or depresses the beards of the needles.

Presser-bar ; the bar which carries the presser in a straight machine.

Shifter. See POINT-SHIFTER (*supra*).

Shogging ; giving endway motion to a bar carrying yarn-guides.

Shifter-bar ; the bar which carries the *shifters*, *points*, or *ticklers*.

Sinker ; a device which presses the yarn down on to and between the needles.

Slack course ; a row of long loops made at the end of a piece of ribbed fabric (a sock-top, for instance), to facilitate its being placed upon the needles of another machine.

Sley ; a grooved or partitioned bed or bar in which the needles or sinkers slide.

Slur-cock ; a cam which depresses the sinkers.

Spring take-up ; a spring-actuated device which bears against the yarn to prevent slackness.

Thread or *yarn guide* or *carrier ;* a device which delivers the yarn or thread to the needles.

Tickler. See POINT-SHIFTER (*supra*).

Welt ; a portion of the knit fabric turned over on itself and fastened down, to prevent raveling ; resembling a hem in woven fabrics.

Work-roller ; the roller upon which the finished fabric is wound.

Besides these are some other terms, some local, probably, some synonyms : —

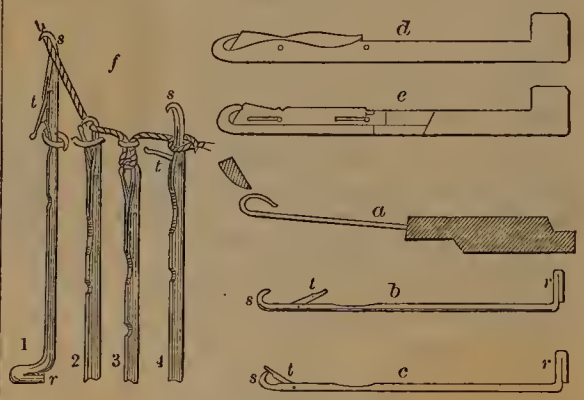
Beater.	Hook.	Neck.
Bowl.	Knock-off.	Shifter.
Catch-bar.	Jack-sinker.	Slur.
Clawker.	Latch-closer.	Warp roller-reel
Fly.	Lifting-bar.	Wiper.

Knit'ting-ma-chine' Jack. (*Knitting-machine.*) One of the set of horizontal levers, to whose ends the *jack-sinkers* are suspended. The *jacks* are moved in succession by a *slur*, which traverses beneath their points, thus moving in consecutive order the jack-sinkers which depress the loops between the needles.

Knit'ting-ma-chine' Nee'dle. The hooked member of the machine which passes through a previously made loop catches the yarn, and retreats through the loop, bringing the bight of the yarn with it, forming another loop. The essential feature of a knitting-machine needle is that it shall catch and draw the yarn to form the loop, and shall cast it off by allowing it to slip over, at another period of the action. The devices for this purpose are flexible beards and latches.

a (Fig. 2773) shows the English knitting-machine needle, which has a hook at one end with a pliable barb, which bends down into a groove in the shank when depressed by a presser-bar. The barbed hook

Fig. 2773.



Knitting-Machine Needles.

then becomes a closed eye ; and if a thread looped over the stem of the needle be drawn forward while the barb is thus closed, it will pass over the barb of the needle and come off at the end. If the thread be drawn forward while the barb is open, it will be caught under the hook. The principal action of the machine depends upon this feature.

b c show two positions of the *latch*-needle : one with the latch lying back, the hook being in condition to catch the thread ; the other showing the hook closed by the latch, which acts as a mousing.

d e are two views of a needle which has a closing slide. The lower view of the two is a section showing the slots which traverse on the pins.

f shows a group of needles with the yarn looped thereon, as when the machine is at work. The needle employed is shown complete at 1. In the other numbers a portion of the lower part is broken away. The needle consists of a body, an angular bent portion or foot *r*, a hook *s*, and a latch *t*. The latter is pivoted to the body of the needle, and works partly in a slot formed in the body. The latch has, moreover, a spoon-shaped end, which, when the latch is closed, as shown in needle 2, meets and partly shuts over the point of the hook *s*, so that the loop formed on the needle easily slips off when the latter makes its downward movement. The needle 1 has passed up through a loop of the previous row, and the hook *s* has caught the yarn ; the mousing-latch is thrown back, as shown also at *b*, same figure. The needle 1 descends, drawing with it the yarn, as shown at 2, the position of the previous needle ; the loop on the

shank has come against the latch *t*, and closed it against the point of the hook, so that the hook and its yarn slip through the loop, which is cast off, as shown at needle 3. Presently the needle commences to rise again, as its turn of work recurs, and, as it does so, as shown at needle 4, the loop lying in the hook slips down the shank, capsizes the latch *t*, and falls over it into the depression in the shank, as shown at needle 1. This is one round of work for a needle. Knitting by machinery is a rapid repetition of these motions.

Knitting-machine needles are made in machines by which the wire is reduced. In Aiken's machine the blanks are clamped in the arbors and brought singly between the grooved rest and rotating cutter, and are reduced by the cutter, which turns in a longitudinal plane, the arbors rotating meanwhile. After the blank has been reduced, it is drawn back from between the rest and cutter, the arbor-wheel is unlocked from the spring detent-pin, and another blank brought into position.

In another machine, for making the tongues of knitting-needles, the machine first forms the bowl and nick of the tongue, and simultaneously forces back the feeder upon the wire. The wire is then moved between the flattening dies ; it is then moved to the punching dies, then to the dies rounding the end next the hole. The tongue with the sharp piece projecting from it is then cut off.

Knit'ting-nee'dle. A plain wire with smoothed ends, used in pairs in hand-knitting of flat goods and in fours for tubular work.

Knit'tle. 1. (*Nautical.*) A small line composed of two or three yarns laid together and twisted with the finger and thumb against the twist of yarn. Used for miscellaneous purposes on board, such as seizings, lashings, hammock-clues, pointing, grafting, etc.

2. A *draw-string* of a bag.

Knob. 1. (*Glass.*) The boss or central bulb of a *table* of glass when cut for use.

2. The handle on the spindle of a lock or latch.

3. A rounded handle of a door, lock, drawer, etc.

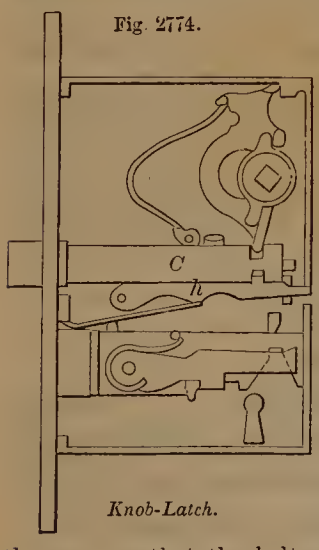
4. (*Architecture.*) A *knop*, bunch, or boss.

5. (*Ordnance.*) The cascabel of a gun.

Knob'bing. (*Masonry.*) The rough dressing, or knocking off the projections of stones in the quarry.

Knob'bling-fire. A sunken refining hearth, of small size, in which crude or partially refined iron is worked into a ball or *knob* in contact with charcoal and under influence of blast. A *bloomary*.

Fig. 2774.



Knob-Latch.

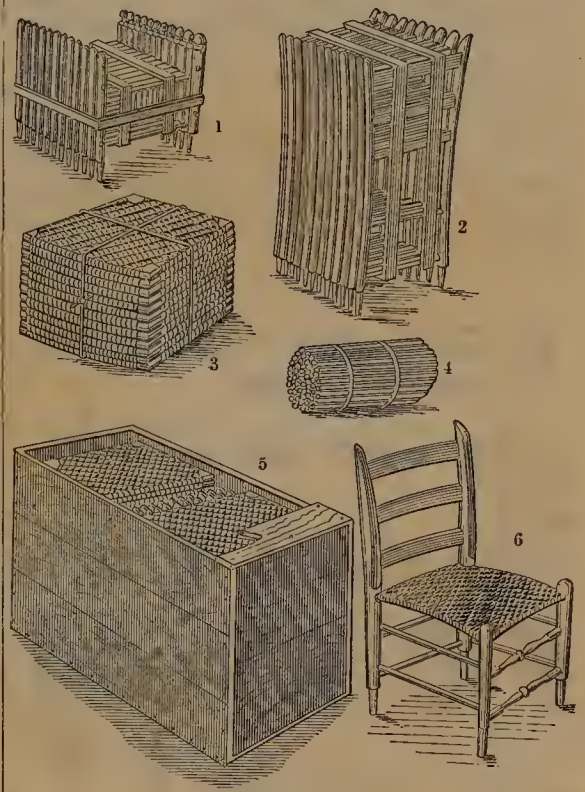
Knob-latch. One in which the bolt is retractable by the knob or rotary handle, in contradistinction to one which is moved by a key. In the example, the latch-bolt *C* rests upon a horizontal bar *h*, one end of which is pivoted to the lock-case, while the other, supported by a spring, protrudes through an opening in the edge of the case, so that the bolt can be disengaged from the arms of the hub by simply depressing the end of the bar.

Knock-down. A piece of furniture or other structure adapted to be disconnected at the joints so as to pack compactly.

The *shook* may be said to be a knock-down barrel.

The example shows the parts of chairs down,

Fig. 2775.

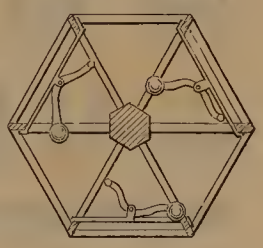


Knock-down Chairs.

bundled, and tied. The different figures show respectively a dozen front legs and rounds, as many backs, seats, side rounds ; also a chair complete and box to hold a dozen knocked down.

Knock'er. 1. An attachment to an exterior door of a house, to give notice to those within that some one stands without.

Fig 2776.



Flour-Bolt Knockers.

2. An attachment in a flour-bolt to jar the frame and shake the flour from the meshes of the bolting-cloth. In the example, the knockers are pivoted weighted arms ; as the bolt revolves, the weights tilt the arms and strike the bolt-frame.

Knock'er-off. (*Knitting.*) A wheel with projections to raise the loop over the top of the needle and discharge it therefrom. A similar wheel, called a *sinker*, depresses the yarn between the needles. See BUR.

Knock'ing. (*Bookbinding.*) Setting even at the edges, by taking a bunch or pile of sheets or leaves and striking an edge on the bench.

Knock'ing-down I'ron. (*Bookbinding.*) An iron for pounding down the projecting twines (*slips*) to which the sheets are sewed, so that they shall not project and mark the back cover.

Knock'ings. 1. (*Metallurgy.*) The larger pieces of ore and gangue which are picked out of the sieve. The sorting of lead ore by the sieve develops

three qualities, *knockings*, *riddlings*, and *fell*. The former are large scraps, which are picked out.

The *riddlings* are what remain in the sieve.

The *fell* is the smallest, and falls through.

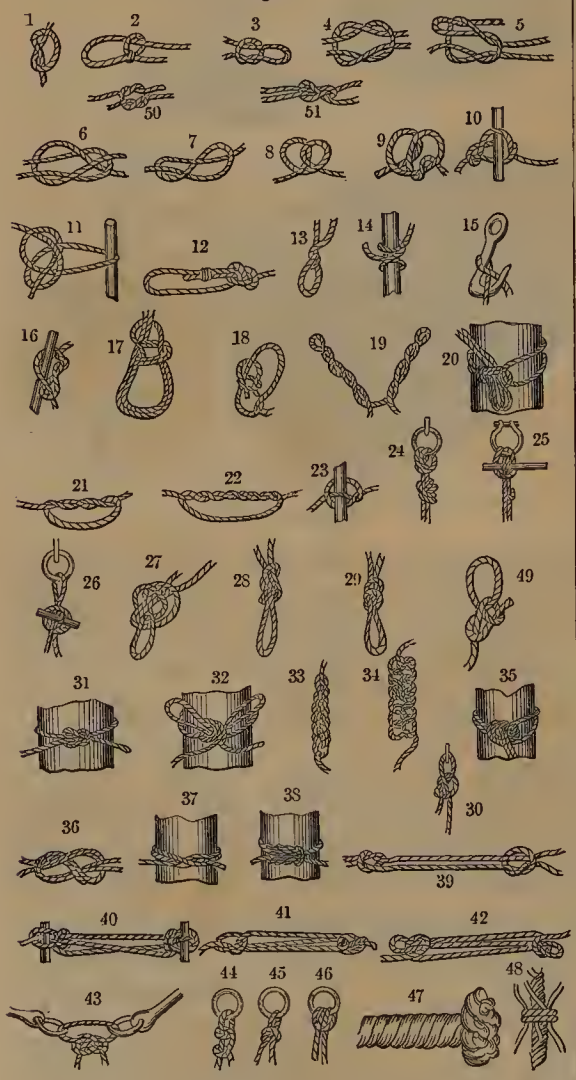
2. (*Masonry.*) The small pieces broken off from stone by hammering or chiseling. Large pieces are *spalls*.

Knock-off. (*Knitting-machine.*) The piece which, at the proper moment, removes the loops from the tier of needles.

Knock-stone. (*Mining.*) A block on which ore is broken.

Knot. 1. (*Nautical.*) *a.* A device formed by intertwining a rope or cord so as to attach one part of it to another part of itself, to another rope, or to any other object. The kinds of knots employed, especially by nautical men, are too numerous to admit of description, and we content ourselves with exhibiting a few of the more prominent.

Fig. 2777.



Knots.

1, simple overhand knot.
2, slip-knot, seized.
3, single bow-knot.
4, square or reef knot.
5, square bow-knot.
6, weaver's knot.
7, German, or figure-of-8 knot.
8, two half-hitches, or artificer's knot.
9, double artificer's knot.
10, simple galley-knot.
11, capstan or prolonge knot.
12, bowline-knot.
13, rolling-hitch.
14, clove-hitch.
15, blackwall-hitch.
16, timber-hitch.
17, bowline on a bight.
18, running-bowline.
19, catspaw.
20, doubled running-knot.
21, double-knot.
22, sixfold-knot.
23, boat-knot.
24, lark's head.
25, lark's head.
26, simple boat-knot.
27, loop-knot.
28, double Flemish knot.
29, running knot, checked.
30, crossed running-knot.
31, lashing-knot.
32, rosette.
33, chain-knot.
34, double chain-knot.
35, double running-knot with cheek-knot.
36, double twist-knot.
37, builder's knot.
38, double Flemish knot.
39, English knot.
40, shortening knot.
41, shortening knot.
42, sheep-shank.
43, dog-shank.
44, mooring-knot.
45, mooring-knot.
46, mooring-knot.
47, pigtail, worked on the end of a rope.
48, shroud-knot.
49, a bend or knot used by sailors in making fast to a spar or to a bucket-handle before casting overboard; it will not run. Also used by horsemen for a loop around the jaw of a colt in breaking; the running end, after passing over the head of the animal and through the loop, will not jam therein.
50, a granny's knot.
51, a weaver's knot.

Those shown are generally in open position, so as to more clearly explain the way in which the parts of the rope run previous to being drawn taut in order to join them together and prevent slipping.

Some kinds of knots are called *hitches* and *bends*, which terms usually indicate that they are chiefly employed for making the rope fast to another object, or for securing two objects together.

The principle of a knot is, that no two parts which would move in the same direction if the rope were to slip should lie alongside of and touching each other.

The *standing-part* of one rope and the *end* of the other should not lie side by side. This feature distinguishes the *sheet-bend*, *bowline-knot*, *carrick-bend*, *reef-knot*, etc., from the *granny's-knot*, *slippery-hitch*, etc.

b. A nautical or geographical mile; $\frac{1}{60}$ of a degree of latitude; about 2,025 yards. The English statute mile is 5,280 feet.

A *log-line* is a *knotted* cord, the distance between the *knots* being $\frac{1}{120}$ of a nautical mile apart, that is, 50 $\frac{7.5}{120}$ feet. The log line is allowed to run out for 30 seconds, which is $\frac{1}{120}$ of an hour, so that the distance between *knots* on the cord bears the same ratio to a degree that the time does to an hour.

Thus if 8 knots on the log-line run through the hand of the seaman while the sand in the $\frac{1}{2}$-minute glass is running out, it is an indication that the vessel is traveling 8 nautical miles per hour. See Log.

2. (*Brush-making.*) The brush-maker's term for a tuft of bristles ready for insertion into a hole drilled in the stock.

3. So many skeins. See Hank.

Knot'ter. (*Paper-making.*) A sieve which detains knots in the pulp, so that they do not pass to the moving wire-plane on which the paper is formed. See Paper-machine.

Knot'ting and Stop'ping. 1. (*Painting.*) A process preliminary to painting, consisting of painting over the knots of wood with red-lead, and the stopping of nail-holes, cracks, and faults with white-lead.

A silver leaf is sometimes laid over the knots in superior work.

2. (*Cloth-making.*) Removing weft knots and others from cloth by means of tweezers.

Knout. The Russian whip for criminals and other offenders.

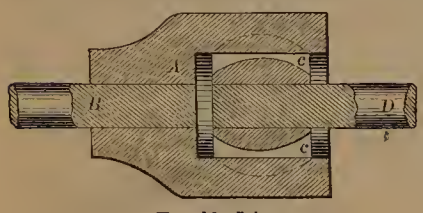
It has a handle 2 feet long, and a thong 4 feet long terminating in a brass ring. To the latter is attached the tail, 2 feet long, and running from 2 inches wide at the ring to a point. This is soaked in milk and dried to harden it. The tail is changed every sixth stroke.

Knubs. The offal or waste silk in winding off from the cocoon.

Knuck'le. 1. (*Mechanics.*) The joint-pieces of a hinge through which the *pintle* passes.

Knuck'le-joint. A joint in which a projection on each leg or leaf of a device is inserted between corresponding recesses in the other, the two being connected by a pin or pivot on which they mutually turn. The legs of dividers and the leaves of butt-hinges are examples of the true knuckle-joint. The term, however, has been somewhat commonly applied to joints in which the motion is not confined to one plane. Such are really universal joints, a form illustrated in the *ball and socket* and the *gimbal*. A *ginglymus*.

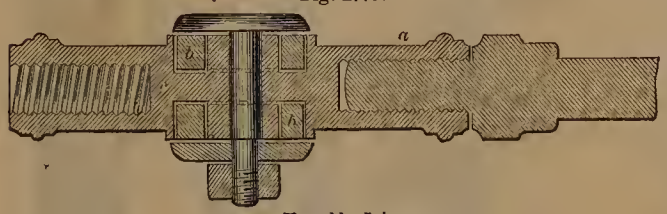
Fig. 2778.



Knuckle-Joint.

The example (Fig. 2778) differs somewhat in character from those just described. In this, designed for coupling the tumbling-rods of thrashers, and for other couplings which require play, the head of the shaft *D* has projections *c* which fit in corresponding grooves in the socket *A*, enabling the rods *B D* to be turned either to the right or the left, as desired.

Fig. 2779.



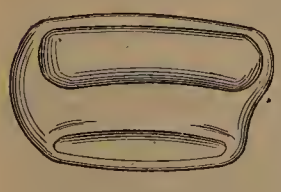
Knuckle-Joint.

In Fig. 2779 the rings *b b* are let into annular recesses in the arms *c a* of the two parts to be coupled, relieving the center-pin from all strain. See COUPLING.

Knuck'le-shield. One to save the knuckles in washing and scrubbing. The example shows one made of india-rubber.

Knuck'le-tim'ber. (*Shipbuilding.*) A top timber in the fore body, where a reverse of shape causes an angle on the timber.

Fig 2780.



Knuckle-Shield.

Knurl'ing. Providing with ridges to assist the grasp, as in the knurled (or milled) head of a set-screw.

Koff. (*Vessel.*) A two-masted, Dutch fishing-vessel, carrying a sprit-sail on each mast.

Kom'pow. (*Fabric.*) A strong, white linen of China.

Kreel. 1. A fish-basket of osiers.

2. A framework fish-trap.

Kris. A short sword of the Malays. A *crease*.

Krum-horn. (*Music.*) A old musical instrument resembling a cornet.

After a singular change of orthography, it is represented by the *crcmona* stop in an organ.

Kus'si-er. (*Music.*) A Turkish musical instrument, having a hollow body, a skin covering, and five strings.

Kutch. (*Gold-beating.*) The packet of vellum leaves in which gold is placed to be beaten.

The package of gold-beater's skin in which gold-leaf is placed for the second beating is called the *shodcr*.

After the second beating, the pieces are cut up and re-arranged in gold-beater's skin, the package being called a *mold*.

Ky'an-iz-ing. Named from Kyan, the inventor of the process (1832). To prevent the decay of wood, cordage, or canvas, it is saturated with a solution of corrosive sublimate in open tanks or under pressure.

The timber is prepared as follows: A wooden tank is put together so that no metal of any kind can come in contact with the solution when the tank is charged. The solution consists of corrosive sublimate and water, in the proportion of 1 pound of corrosive sublimate to 10 gallons of water as a maximum strength, and 1 pound to 15 gallons as a minimum, according to the porosity or absorption of the timber subjected to the process.

Oak and fir timber absorb nearly alike, but some other woods, such as beech, poplar, elm, etc., are more porous.

The period required for saturating timber depends on its thickness; 24 hours are required for each inch in thickness, for boards and small timbers.

The timbers, after saturation, should be placed under a shed or cover from the sun and rain, to dry gradually.

In about 14 days timber not exceeding 3 inches in thickness will be perfectly dry and seasoned, and fit for use. Large timbers will require a proportionate time, according to their thickness.

Some processes of similar import may be shortly stated.

In Bethel's process, creosote is employed and forced under heavy pressure into the pores of the wood. (1838.)

Robbins expels moisture by heat and then saturates with coal-tar, resin, or bituminous oils, at 325° Fah. (1865).

Blythe treats with steam combined with hydrocarbon vapor.

Burnett employs chloride of zinc in solution, under pressure. (1838.)

Boucherie used pyrolignite of iron. (1840.)

Payne, sulphate of iron. (1842.)

Margary, acetate or sulphate of copper. (1837.)

Van der Weyde, solution of silicate of potash.

Heinemann: boil wood in alkaline solution, and treat, under pressure and heat, with resin, carbolic acid, and tar.

Nicholson, tar and petroleum.

Behr, solution of borax.

Earl, protosulphate of iron.

Payen, superficial carbonization. See WOOD, PRESERVATION OF.

L.

La'bel. A placard or slip attached to an object to indicate contents, destination, or ownership. See BAGGAGE-CHECK, for instance.

1. Animal labels are of many forms : —

a. A metallic strip bent into a link-shape, the ends being passed through two slits in the ear. On the outside is shown the name of the owner or the number of the animal on the stock-book.

b. A plate secured by rivet to the ear.

c. A button is inscribed with the name of the owner and fastened to the ear by means of a locking plate, which enters the tubular shank of the button.

d. A tag attached to the horns, wool, mane, etc., to indicate ownership, class, prize, merit, etc.

2. A card or tablet attached to a bottle, jar, drawer, etc., by a chain, or placed in a panel.

One on a can of fruit or other vegetables. In one case, the whole series of customary contents are placed on the margin of the can, and the kind contained in the can is indicated by a mark.

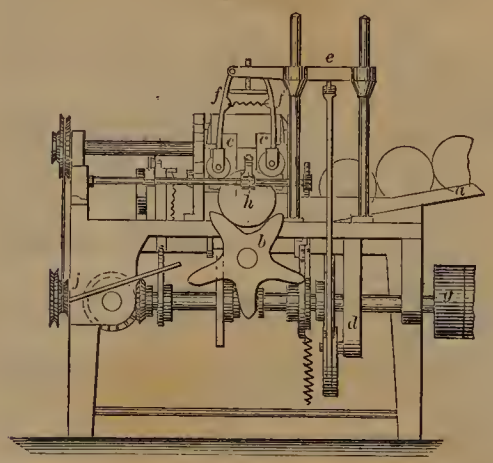
3. A brass rule with sights, formerly used in connection with a circumferentor to take altitudes.

4. (*Architecture.*) A molding over a doorway or window. A *head-molding* or *hood-molding* in the interior ; a *drip*, *drip-stone*, or *weather-molding*, on the exterior.

La'bel-cor'bel Ta'ble. (*Architecture.*) A corbel-supported head-molding over a doorway or window. Known also as a *drip-stone* or *hood-molding*.

La'bel-ing-ma-chine'. A device for attaching labels to cans, jars, or bottles. The example shows

Fig. 2781.



Labeling-Machine.

one form, in which the can is fed in at the chute *a*, and is taken up by the revolving star *b*. It is there retained in place long enough to receive the label from the gumming-wings *c*. The cam *d* gives downward motion to the cross-head *e*, and thence to the arms *f f* with the smoothing-rollers attached thereto. The can is then discharged by a partial revolution of the star *b* on to the chute *j*. Power is applied at *g*. The finger *h* holds the label in place while the gumming-wings return for another label. It takes in four sizes of cans, and has labeled 9,000 in ten hours.

Lab-i-dom'e-ter. A forceps with a measuring attachment for ascertaining the size of the fetal head.

Lab'o-ra-to-ry. 1. A house or apartment in which chemical experiments are conducted.

2. A manufactory of chemical articles.

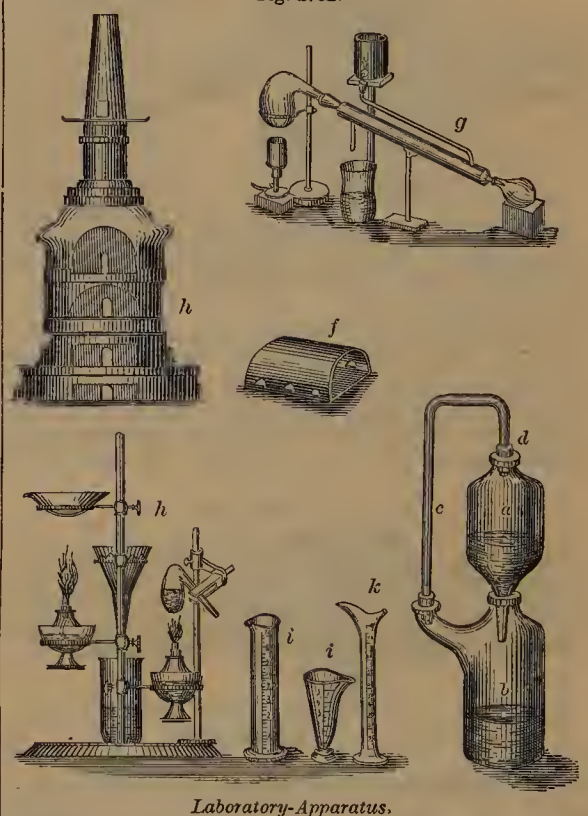
3. A place where fireworks are prepared.

4. A department in an arsenal where cartridges, fuses, primers, etc., are made, shells charged, etc.

Lab'o-ra-to-ry-ap-pa-ra'tus. Instruments and appliances used by the chemist in his study. Among them may be cited the cupellation-furnace *h*, cupel *f*, Liebig's condenser *g*, the retort and filter-stand *h*, measuring-glasses *i i*, pipette *k*.

A *filter* for chemical solutions, without access of fresh bodies of atmospheric air, is also shown in the figure ; the vessel *a* containing the solution and the

Fig. 2782.



Laboratory-Apparatus.

filtering-matter occupies the neck. As the liquid reaches the vessel *b* it displaces a body of air, which passes by the pipe *c* to the chamber *a*, entering through the stopple *d*, which is ground or provided with cork. See also BALANCE.

Lab'y-rinth. (*Metallurgy.*) *a.* A sinuous channel in which the ground ore (*slime*) and water are conducted, in order that the metallic portions may be deposited according to their respective gravities.

b. A chamber of many turnings in which fumes, derived from dry distillation of mercury, etc., are condensed. See CONDENSER.

Lac. A resin obtained from the *Ficus indica*. See RESIN.

Lace. A kind of network of threads of flax, cotton, gold or silver wire, or other suitable material, forming a fabric of transparent texture. Its origin is not known, but it appears to have been used by the ladies of ancient Greece and Rome. It was early used in Northern Italy, and is said to have been introduced into France by Mary de Medicis. In 1483 its importation into England was prohibited.

The systematic manufacture was introduced into England by refugees from Flanders.

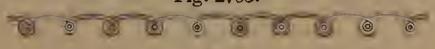
Lace was anciently worked by the needle. The invention of lace *knitting* is attributed to Barbara, wife of Christopher Huttman, a German miner, in 1560. A manufactory was established in France by Colbert, in 1566.

Point lace was embroidered with the needle. *Bone* lace (temp. of Charles I.) was a kind of thread lace, and received its name from the bobbins being made of bone. About 1768, a stocking-weaver of Northampton produced a machine for making lace; it was called the *pin-frame*, and is still employed in France for making the lace called *tulle*.

The method of Barbara Huttman is as follows: The lace-maker has a hard cushion in her lap on which the pattern, traced on parchment, is laid, and pins passed through the parchment into the cushion at places determined by the pattern. She has also a number of bobbins on which the threads are wound, fine thread being used for the meshes or net. The work is begun by attaching the threads in pairs to the pins. The threads are then intertwined by means of the bobbins, so as to form the required pattern.

In *lace-weaving*, the threads of the weft are twisted round those of the warp. The manner of twisting determines the character of the net and its name,

Fig. 2783.



Lace-Weaving.

as *whip*-net, *mail*-net, *pattern*-net, *drop*-net, *spider*-net, *balloon*-net, *Paris*-net, *bobbin*-net.

The classification of laces at the English exhibition of 1851 was as follows: —

1. *Pillow-lace*, the article or fabric being wholly made by hand (known as *Valenciennes*, *Mechlin*, *Honiton*, *Buckingham*); or *Guipure* made by the crochet-needle; and *silk lace*, called *blonde* when white, and *Chantilly*, *Puy*, *Grammont*, and *black Buckinghamshire*, when black.

2. Lace, the ground being machine-wrought, the ornamentation made on the *pillow* and afterwards applied to the ground (known as *Brussels*, *Honiton*, or *appliquée lace*).

3. Machine-made net or quillings, wholly plain, whether warp or bobbin (known as *bobbin-net*, *tulles*, *blondes*, *Cambraie*, *Mechlin*, *Malines*, *Brussels*, *Alençon*, etc.).

4. Lace, the ground being wholly made by machine, partly ornamented by machine and partly by hand, or wholly ornamented by hand, whether tamboured, needle-embroidered, or darned.

5. Lace, wrought and ornamented by machinery, comprising *trimming laces* of every description, *veils*, *falls*, *scarfs*, *shawls*, *lappets*, *curtains*, etc.

The dates of some of the inventions connected with lace-making are as follows: —

Bobbin-lace invented by Barbara Huttman of St. Annaberg, Germany	1561.
Pillow-lace making taught at Gt. Marlow, England	1626.
Strutt's machine for making openwork stockings	1758.
Crane's Vandyke machine	1758.
Else and Harvey's "pin" machine	1770.
Frost's point-net machine	1777.
Dawson's point-net machine	1791.
Heathcoat's bobbin-net machine	1804.
Hill's plain ground net machine	1816
"Limerick" lace made	1829.

Laced-stock'ing. A bandage support for varicose veins, weak legs, etc.

Lace-mak'ing Ma-chine'. Lace is a delicate kind of network composed of silk, flax, or cotton threads, twisted or plaited together. See LACE.

The meshes are of an hexagonal figure, in which thick threads are also interwoven to form the pattern, according to some design; and these threads, which are called *gymp*, form the ornament of the lace.

The *point-net frame* was invented by Morris (England) in 1764, and is a variety of the stocking-frame, making a stitch or loop like that of a stocking, and formed by a continuance of one thread. The thread is by the machine formed into loops, a whole course at once, by pressing it down alternately over and under between a number of parallel needles. A second course is then made of similar loops on the same needles, and the loops of the first are drawn through those of the second in such a manner as to form meshes by retaining the first loops; the second are then retained by a third, and these by a fourth, and so on.

The *warp-net frame* is also a variety of the stocking-frame, but the parts are very differently arranged, the movements being produced by treadles, leaving the hands of the workman to manage the machine, which is a piece of mechanism applied in front of the row of needles of the frame. In the *warp-net frame* the piece of lace is not formed of one continuous thread, as in the *point-net frame*, but there are as many different threads as there are needles in the frame; these threads are *warped* or wound upon a roller or beam the same as a loom, and it is from this circumstance that the machine is called a *warp-frame*. These threads pass through eyes in the ends of small points, called *guides*, which are opposite the needles; and these guides are fixed on two bars, each of which has half the guides fastened on it; that is, one guide is fast to one bar, and the next to the other, and so on alternately of the whole. Each of the guides presents a thread to its needle, and all are at once moved by the hand to twist the threads two or three times round the needles that are opposite to them. The loop is now made in a manner similar to that in the *point-net frame*. The next time, the alternate guides are shifted endways, so as to apply themselves to other needles than those they were opposite to before; this crosses the thread so as to make a net, but the quantity that is shifted endways is changed every time by means of the machinery, so as to move a certain number of needles, which number is changed every time to produce the pattern.

The lace-making machine for weaving the real twisted lace, like that made on the pillow, was invented by Heatheoat, 1804.

The groundwork of the invention is to extend those threads which form the warp of the lace in parallel lines, and dispose the diagonal threads upon small bobbins, which are detached, and are capable of passing round the extended warp-threads so as to twist with them; by this means the number of bobbins is reduced to one half. In this machine there are two horizontal beams or rollers, one to contain the thread and the other to receive the lace; also a number of small bobbins to contain the thread.

Mr. Hebert thus enumerates the varieties of bobbin net-lace machines: —

The Loughborough double-tier	*Heathcoat's.*
The single-tier	*Stevenson's.*
The improved double-tier	*Brailey's.*
The improved single-tier	*Lever's.*
The Loughborough improved; with pumping-tackle.	
The pusher principle.	
The traverse warp	*Bevan & Freeman's.*
The traverse warp, rotary	*Lindley & Lacey's.*
The straight bolt	*Kendal & Mauley's.*
The circular bolt	*Mauley's.*
The circular comb	*Hervey's.*
The improved circular comb	*Hervey's.*
The farther improved single tier	*Lever's.*

Lace-pa'per. Paper having an openwork pattern and perforations made in imitation of lace. The process usually consists in grinding off the elevated portions of embossed paper, which is accomplished by passing the paper between two rollers, one of which is covered with ground glass or emery, the other is impressed with a duplicate of the design on the paper. The grinding-roller is made to revolve at high velocity.

Lace-piece. 1. (*Shipbuilding.*) The main-piece of the head, or beak-shaped projection from the *head* of a vessel. See MAIN-PIECE ; STEM.

2. (*Nautical.*) The rope used to fasten a sail to its yard or gaff.

Lach'ry-mal-duct Di-lat'or. (*Surgical.*) A probe, by means of which the normal caliber of the nasal duct, in cases of obstruction, is restored. They are made of eight different sizes, of silver, lead, whalebone, hard rubber, and *laminaria digitata.* The silver is the most useful ; whalebone and hard rubber are easy to guide, and less liable to injure the mucous membrane. The *laminaria*, after introduction, gradually swells up from imbibition of the tears, and thus dilates the canal.

Lac'ing. 1. A fastening by a cord, thong, or whang, which passes through holes prepared in the respective parts of the object so fastened. The term is applied to fastening up the front opening of some kinds of boots ; also to the fastening together of the pieces which constitute a machine belt.

2. (*Bookbinding.*) Securing the book to the sides by carrying the bands or slips through perforations in the boards.

3. (*Nautical.*) The rope used to confine the heads of sails to their gaffs or yards.

Lac'quer. Primarily, a varnish composed of shellac dissolved in alcohol and colored by means of gamboge, saffron, annotto, and various other coloring matters. It is applied to wood, to papier-maché, and to metals to protect them from rust and improve their color. The term is also applied to compositions containing none of the above ingredients, they being replaced by turpentine, resin, etc.

The proportions of the shellac and alcohol vary. Two gallons of alcohol to one pound of shellac is probably the most common proportion.

Besides the coloring matters above referred to, turmeric, dragon's blood, gum sandarach, and red saunders are frequently employed in red and gold colored lacquers, the articles and their relative proportions being varied according to the tint desired. In the military service the following lacquers are used : —

For Small-Arms, or Water-Proof Paper.

Beeswax	13 pounds.
Spirits turpentine . .	13 gallons.
Boiled linseed-oil . .	1 gallon.

All the ingredients should be pure and of the best quality. Heat them together in a copper or earthen vessel over a gentle fire, in a water-bath, until they are well mixed.

For Bright Iron Work.

Linseed-oil, boiled . . .	80.5
Litharge	5.5
White-lead, in oil	11.25
Resin, pulverized . . .	2.75

Add the litharge to the oil ; let it simmer over a slow fire three hours ; strain it, and add the resin and white-lead ; keep it gently warmed, and stir it until the resin is dissolved. For ordnance, shot, or shells, or other iron work not designed to be kept bright, coal tar thinned with spirits of turpentine forms a very cheap and permanent lacquer.

Lac-tom'e-ter. Called also galactomer. A species of hydrometer, graduated to show the comparative specific gravity and consequent value of different specimens of milk.

The instrument is a good evidence of the specific gravity of milk, and the specific gravity is a probable, but not positive, evidence of quality. Taken in connection with the per-cent glass, which measures the per cent of cream that rises, it is nearly a positive indicator of pure and watered milk.

One form of the *lactometer* for ascertaining the amount of cream in milk consists of a tube with a funnel mouth for convenience in charging it, and having the upper portion graduated. The tube is about a foot in length, and being filled the cream is allowed to rise, when its richness is determined by the number of graduated spaces occupied by the cream.

The hydrometer alone is not adapted to determine the amount of cream in milk, which can only readily be determined by test. Dr. Ure suggests it may be applied to the skimmed milk to determine the proportions of curds and whey.

Lac'to-scope. An instrument invented by Donne of Paris, for assisting in determining the quality of milk by ascertaining its relative opacity.

The "three times skimmed sky blue" of Bloomfield is the bottom of the scale, unless the pump-water milk for urban distribution is considered as zero.

Dingler's "Polytechnisches Journal" describes a simple apparatus for determining the richness of milk, as measured by its transparency. Two polished plates of glass are adjusted by means of a screw to stand at different distances from each other. The milk is placed between them, and the distance of the plates from each other when the flame of a stearine candle is rendered invisible, is the measure alike of the transparency and comparative richness of the milk.

Lac-var'nish. One made from shellac dissolved in alcohol. Colored by red, orange, or yellow matters. Lac is obtained from the *Ficus indica*, and the product is *stick lac*, *seed-lac*, *shellac*, and *lac-lake.*

Lad'der. 1. A frame — usually movable — having a series of steps attached to side-bars or ropes. The varieties are distinguished by their purposes, position, or by some feature of construction.

A *ladder* differs from a *stairs* in that the latter has *treads* and risers, being thus boxed in below. The *ladder* has merely *steps.*

Of the *nautical* ladders, we have, —

Accommodation-ladder.
Companion-ladder.
Forecastle-ladder.
Hold-ladder.
Jacob's-ladder.
Quarter-ladder.
Side-ladder.
Stern-ladder.

As to purpose, we have, —

Fire-escape.
Fire-ladder.
Fruit-ladder.
Garden-ladder.
Scaling-ladder.

The names denoting construction are, —

Chain-ladder.
Extension-ladder.
Rope-ladder.
Rule-joint ladder.
Step-ladder.

Fig. 2784.

Collapsing-Ladder.

The *collapsing-ladder* (Fig. 2784) has rounds pivoted to the side-rails, recesses in which receive them when the ladder is folded. When the side-pieces are drawn apart, the rounds assume a horizontal position.

A movable ladder is sometimes used in ascending and descending shafts. Two poles ascend and descend alternately, and have stages on to or from which the person steps from or to the corresponding step on the other pole, at the moment when they become stationary. See MAN-ENGINE.

Scaling-ladders are shown in the triumphal monuments of Rameses II., the great Sesostris, 1355 B. C.

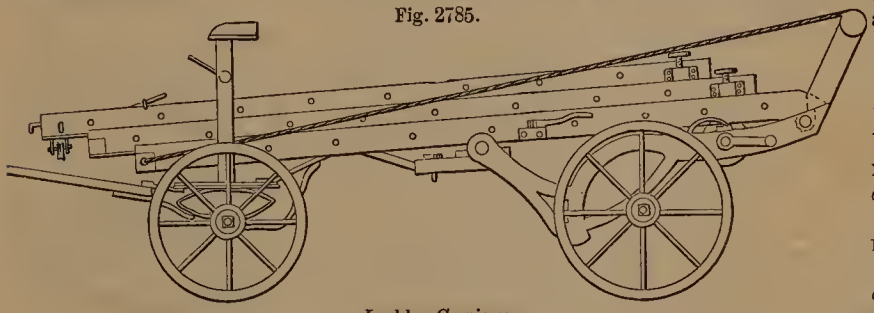
The first ladder of record was that seen by Jacob in his dream, and it is the longest and best of which we have any account. It is the only one mentioned in the Bible.

2. (*Nautical.*) The *accommodation*-ladder is a stairs slung at the gangway. The *forecastle* and *hold* ladders are at these respective places. The *Jacob's*-ladder abaft the top-gallant masts, where there are no ratlines at the shrouds. The *quarter* and *stern* ladders are for reaching or leaving the boats moored astern.

3. A notched cleat or stick in a bookcase, for supporting shelves.

Lad'der-car'riage. One for conveying fire-ladders. In the example, the bed-frame serves as a connection in coupling the wagon, and braces the ladder when raised. The windlass, having its bearings at the foot of the frame, extends the sliding sections of the ladder. The basket, attached by a rope to the pulley at the top of the ladder, forms a fire-escape.

Fig. 2785.



Ladder-Carriage.

Lad'der-way. 1. (*Mining.*) Or foot-way shaft. The shaft of a mine, by which the workmen ascend and descend.

2. (*Nautical.*) A *companion*-way or *scuttle*-way on board ship.

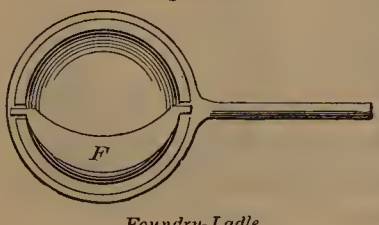
La'dies. (*Skating.*) A size of skates; 15 × 18 inches.

La'ding. (*Glass.*) The transference in cisterns of molten glass from the pot to the table, in plate-glass making.

La'ding-hole. (*Glass.*) An aperture in the side of a furnace for plate-glass, at which the *cuvette* for carrying the metal is introduced or is filled. See page 669.

La'dle. 1. (*Founding.*) A pan with a handle to hold molten metal.

Fig. 2786.



Foundry-Ladle.

On a small scale, the *bullet-ladle* is a familiar instance.

The large ladle used in the foundry is called a SHANKS (which see).

Ladles are protected by a thin coat or layer of loam, and every time, before being used, they are brushed over with black wash and carefully dried.

The example has a lunate-shaped plate *F* pivoted to the rim, and serving to keep back impurities floating on the metal.

2. (*Ordnance.*) An implement used for removing the shot when it is not wished to fire the gun. It is a semi-cylinder of copper, beveled at the end, and attached to a staff. For use, the muzzle of the gun is slightly depressed and the ladle passed in so as to run under the shot, which is received in it; when the ladle is withdrawn, it brings the shot out with it.

b. A cylindrical scoop of copper for loading loose powder into a cannon.

3. (*Pyrotechnics.*) A copper scoop for filling rockets.

4. (*Glass.*) A vessel in which molten glass is carried. A *cuvette.*

5. (*Domestic.*) A large dipping spoon.

6. (*Hydraulics.*) The float-board of a mill-wheel.

La'dle-board. A mill-wheel float.

Lag. 1. One of the boards or staves forming the covering of a large band-drum, or the upper casing of a carding-machine, or the covering of a steam-boiler or cylinder.

The *lags* of the drum are fastened by *lag-screws* to the frame of the wheel.

The *lags* of the carding-machine are *clothed* with *cards* on the under sides, and are separately removable.

The *lags* of the boiler or cylinder are wooden staves, hooped, and enclosing a body of non-conducting material. Otherwise called *cleading.*

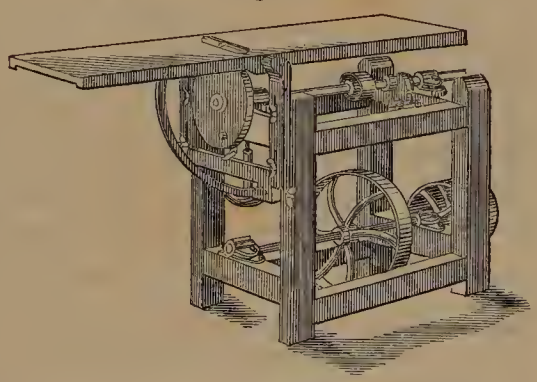
2. (*Steam-engine.*) The retardation of the valve.

Lag'ging. 1. (*Steam-engine.*) The non-conducting jacket or clothing of a steam-boiler or cylinder, to prevent radiation of heat. *Cleading, deading, sheathing, clothing.*

2. (*Carpentry.*) Narrow planks extending from one rib to another in the centering of arches and forming the board covering upon which the courses of voussoirs are laid.

Lag-ma-chine'. (*Wood-working.*) A machine for hollowing out the insides of *lags* or covering for wooden rolls or drums; or the *cleading* for jacketing cylinders or steam-pipes.

Fig 2787.



Lag-Machine.

Lag-screw. A flat-headed screw used to attach lags to band-drums.

Laid. (*Paper.*) Paper having the marks made by the wires of the *deckle*.

The choice of coloring matter occasions the names *cream-laid, blue-laid*, etc.

Laid-on. (*Joinery.*) A term applied to moldings which are got out in strips and nailed on to the surface of the object.

Laid-pa'per. Paper made with a ribbed surface like that formerly made in the hand-frame.

Lam'bre-quin. 1. A curtain on the helmet to protect from the rays of the sun, like the cap with a valance named from the East Indian hero "Havelock."

2. A festooned drapery, forming an ornament at the upper part of a window, and covering the curtain rings and bar.

Lamb's Tongue. A plane with a deep, narrow bit for making quirks.

Lam'e-ro. A walled receiver, where the *slimes* (mud charged with auriferous or argentiferous particles, or both) are deposited from the arrastra, to part with a portion of their water, and accumulate till sufficient to form a *torta*, in which the amalgamation is performed. See AMALGAMATOR.

Lam'i-na-ted Arch. A timber arch made of successive thicknesses of planking bent on to a centering and secured together by tree-nails. See ARCHED BEAM.

The Ouseburn Viaduct of the Newcastle and Tynemouth Railroad, England, was erected on this principle. It is 108 feet high, and consists of 5 arches, each 116 feet span, and two stone arches at each end, 45 feet span.

Another bridge has 7 arches of 120 feet each.

Each arch has 3 segmental ribs, each of which has 30 deck deals, 3 inches wide, being 2 deals in width and 15 in height. The deals vary from 20 to 45 feet in length, and are laid so as to break joint. They are connected by oak treenails, each of which passes through 3 thicknesses. A layer of brown paper dipped in boiling tar is laid between thicknesses. The ends of the ribs are let into cast-iron shoes, which are fixed to the imposts of the masonry piers. The ribs are connected by diagonal braces and iron ties. The spandrels are strongly framed. All the wood-work was *kyanized*.

Lam'i-na-ted Pipe. Water, sewer, or gas pipe made of thicknesses of veneer or scale board successively wrapped to obtain thickness and strength. Each layer is thoroughly saturated with asphalt, and the grain of alternate layers passes in transverse directions, so as to secure an intimate bond and a line of resistance to disruption in any direction, lengthwise, oblique, or across the pipe circumference. The veneer is sometimes made to alternate with fabric or an adhesive composition.

Lam'i-na-ted Rib. An arched beam made of planks bent, laid flatwise in layers, and secured by bolts. See ARCHED BEAM.

Lam'i-nat-ing-ma-chine'. A gold-beater's rolling-mill for reducing the *ingot* of gold to such a thickness that a square inch will weigh 6½ grains. The ingot weighs 2 ounces, and is ⅝ inch broad. The rollers are of hard steel, and extend the ingot to a *ribbon*. The gold is frequently annealed during the process.

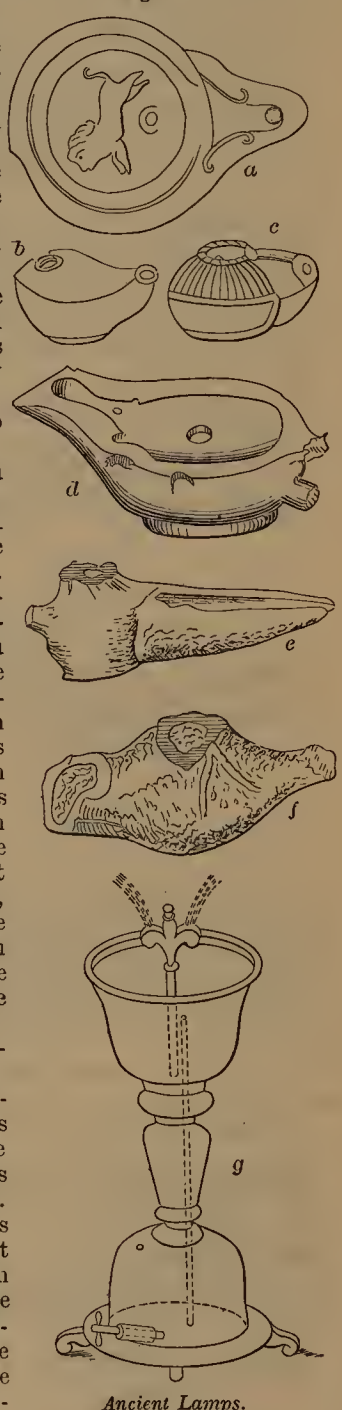
Lam'i-nat-ing-roll'er. (*Metal-working.*) One of a set by which a fagot or bloom is drawn out into a bar or sheet.

Lamp. A device in which an artificial light is produced by the burning of a wick saturated in oil or liquid fat.

Lamps were used before candles. The oil was conducted to the flame by means of a wick, before man learned to use the suet which hardened upon a wick and made a rigid rod of grease.

"The invention of artificial light has extended the available term of human life, by giving the night to his use; it has, by the social intercourse it encourages, polished his manners and refined his tastes, perhaps, as much as anything else, has aided his intellectual progress." — DRAPER.

Fig. 2788.



Ancient Lamps.

Lamps were used in early ages in all the ancient civilized countries, China, India, Egypt, Greece, and Rome. Many beautiful forms from these countries are to be found in collections: especially from the excavations of Pompeii. Sepulchral lamps were commonly placed in tombs, and have thus been preserved in many cases.

Homer makes no mention of them, though they had been long in use in Egypt, and it is understood that he had seen the Thebes he portrayed. The upper three figures, *a b c*, are representations of Egyptian lamps found in the tombs. The constellation Leo, shown upon the largest lamp, was *the* favorite sign in Egypt, for then Osiris (the Nile) came forth and embraced all the fertile land of Egypt even unto the desert, and retiring left the fertile deposit, from which sprung all the productions of the country.

d c f are ancient European lamps.

The Egyptians, according to Clemens Alexandrinus, were the first who used lamps in their temples. Green porcelain lamps were found in the great pyramids of Ghizeh and Sakkarah. The festival of Isis at Busiris was called the Feast of Lamps. The lamps had wicks floating in oil which rested on salt-water. They were used in the tabernacle and in the temple of the Jews.

In Hero's "Spiritalia," 150 B. C., is a description of a lamp (*g*) in which a supply of oil from a reservoir below is driven up by means of air introduced into the base by an air-pump. In another form of Hero's lamp, the oil is raised by water, introduced below the oil by means of a pipe.

"Al-mansúr first caused wax to be burnt in the interior [of the mosque of Cordova] in addition to oil, thus combining the effect of both lights." — Makkari's (Arabic) "History of the Mohammedan Dynasties of Spain."

For varieties, see under the following heads: —

Annealing-lamp.	Miner's lamp.
Aphlogistic-lamp.	Monochromatic lamp.
Argand-lamp.	Petroleum-lamp.
Astral-lamp.	Pump-lamp.
Carcel-lamp.	Safety-lamp.
Car-lantern.	Signal-lamp.
Clock-work lamp.	Singeing-lamp.
Davy-lamp.	Sinumbra-lamp.
Dobereiner's lamp.	Solar-lamp.
Electrical lamp.	Street-lamp.
Fountain-reservoir lamp.	Student's lamp.
Frost-lamp.	Submarine lamp.
Hydrogen-lamp.	Sun-burner.
Hydrostatic lamp.	Switch-lantern.
Lamp-stove.	Tar-lamp.
Lantern.	Vapor-burner.
Magnesium-lamp.	Vapor-lamp.
Mechanical lamp.	

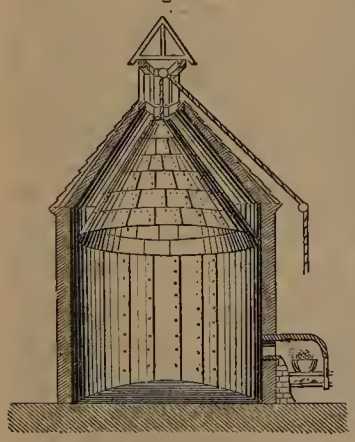
Lamp'black. A black pigment, consisting of pure charcoal, the particles of which are in a very fine state of division. It is principally prepared from refuse tar, resin, or turpentine, though it may be produced from a variety of other substances, animal and vegetable.

The tar, resin, etc., is burned in iron pots or a furnace, a quantity of air just sufficient to support combustion being admitted, in order to produce a dense smoke with little flame.

The smoke is let into cylindrical iron chambers, lined with sheepskin, woolen cloth, or canvas. Each chamber is provided with a roof fitting within it and suspended by a pulley and chain. This is lowered occasionally, scraping the lampblack from the sides of the cylinder, and depositing it on the bottom, whence it is removed through a small door by means of a hoe or scraper. A series of chambers may be used, communicating with each other by horizontal passages. In this case the roof of the last is partially open at top to permit a draft. The black deposited in this is the finest of all, but contains more or less resinous and oleaginous matter. This is removed by heating the black to a red heat in cast-iron boxes with close covers, and maintaining it at that temperature for two or three hours.

Ivory-black, largely used as a pigment, and bone-black, employed in refining sugars, are produced from animal bones. A bluish black, termed peach-black, is derived from the combustion of peach kernels.

Fig. 2789.

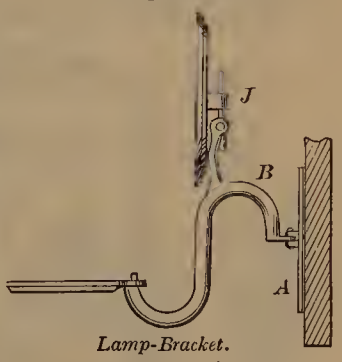


Lampblack-Furnace.

Lamp'black-fur'nace. A cylindrical chamber lined with sheepskin or canvas, and having a conical top. The top is provided with a cowl through which the more volatile products of combustion escape, the carbon adhering to the lining of the chamber. At one side is a smaller communicating compartment provided with a grate, on which a vessel containing the hydrocarbon, resin, coal-tar, or similar substance, is placed, and heated by a fire beneath.

When a sufficient quantity of black has accumulated, a cone, having a small perforation at its summit, suspended within the main chamber, is lowered, scraping off the deposit accumulated on the lining, and causing it to fall to the bottom, whence it is removed by a suitable implement. In this state it contains resinous, bituminous, and other impurities, which are driven off by heating to redness in a close vessel, leaving nearly pure charcoal in an extremely comminuted state.

Fig. 2790.

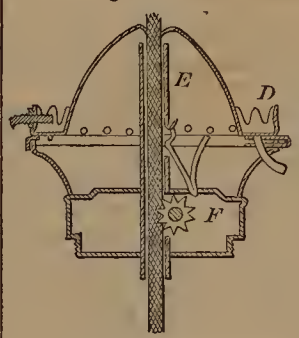


Lamp-Bracket.

Lamp-brack'et. A branch extending from a wall or pillar, to hold a lamp. *C* is the ring for the lamp-bowl, *K* the reflector which slips on the pin *J* of the bracket *B*, which is hinged to the plate so as to swing horizontally.

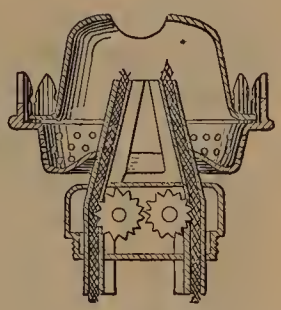
Lamp-burn'er. The portion of a lamp at which the wick is exposed and ignited. It has devices for adjusting the wick, and its crowning portion is usually such as to deflect a current of air upon the wick to insure a more perfect combustion. In the example, *F* is the wick-raising wheel, *E* the wick-tube, *D* the gallery for the flanged foot of the lamp-chimney.

Fig. 2791.



Lamp-Burner.

Fig 2792.



Double-Wick Burner.

In Fig. 2792 the wicks in the two curved tubes are raised simultaneously by two serrated wheels, which mash together. The air passes upward both within and outside the wick-tubes.

Lamp-ce-ment'. A cement for brass mountings on glass, such as on lamps, is made by boiling resin 3 with caustic soda 1 in water 5, thus making a kind of soap, which is mixed with half its weight of plaster of paris, zinc-white, white-lead, or precipitated chalk. It is unaffected by petroleum or similar burning-fluids.

Lamp-chim'ney. The glass funnel which increases the draft and protects the flame of a lamp.

L'Auge invented the lamp-chimney. He added it to the tubular wick and central air-tube of Argand's lamp, and perfected the invention.

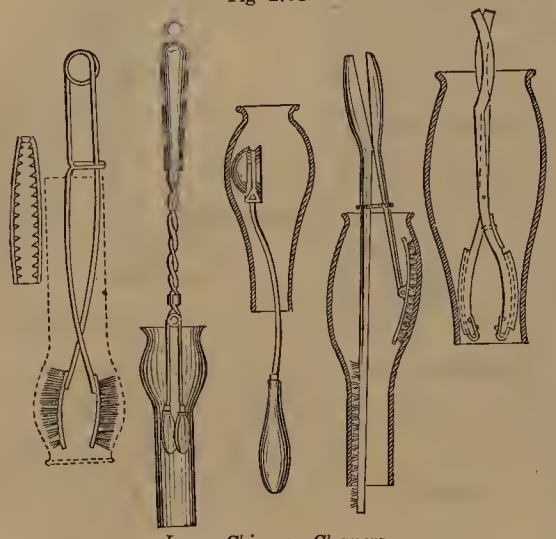
Lamp-chimneys are usually of glass, but have been made of mica, metal with mica windows, horn, and porcelain. Their forms are various, from the straight cylinder of the German student's lamp to

the obese bulb of commoner varieties. They have also been made in various convoluted and spiral forms, designed to give greater liberty of expansion with changes of temperature. They have also been split longitudinally, spirally, and made with holes, the intention being in each case to make them less liable to fracture by heat or a blow.

Lamp-chim'ney Ad-just'er. A means for raising and lowering a glass lamp-chimney in order to modify the draft, or to allow the wick to be snuffed without lifting off the chimney.

Lamp-chim'ney Clean'er. (*Domestic.*) A pad or brush for cleaning the chimneys and glasses

Fig 2793.

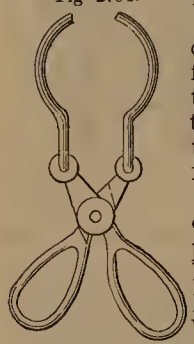


Lamp-Chimney Cleaners.

of lamps. It is usually made expanding, so as to bear upon opposite portions of the inside. A few of the many varieties are shown in Fig. 2793.

Lamp-chim'ney Tongs. An implement for grasping a hot lamp-chimney and removing or replacing it.

Fig 2794.



Lamp-Chimney Tongs.

Lamp-cone. A domc-shaped or conical cap, with a slit for the flame, and placed over and around the wick and wick-tube of a lamp, to concentrate the current of air at throat of the cone. See LAMP-BURNER.

Lamp-el'e-va-tor. A means of adjusting the hight of a suspended lamp in a room. It usually has a telescopic tube, lazy-tongs, or pulleys and chains, with counter-weights. See DROP-LIGHT.

Lamp-hang'er. A means of suspending a lamp, consisting of a ring and chains, or other device.

Lamp-post. A stand for a street-lamp, usually adapted for gas; the pipe rises inside the hollow post, with a burner on top surrounded by a glazed lantern.

Lamp-posts are made to subserve other purposes, such as holding basins for drinking-fountains, the water being conducted up the hollow of the post. Through the same may also pass the wires whereby the jet of gas is lighted by elcetric action.

Lam'pro-type. (*Photography.*) A polished collodion picture; from the Gr. *lampros*, beautiful.

Lamp-shade. A screen placed above the light to intercept or mellow it. It may have a dark exterior and reflecting interior surface. In the list below are some comparisons of transparent and partially opaque materials.

Loss of Light by Use of Shades and Colored Media.
(F. H. Storer and Allan Stevenson.)

Glass, etc.	Thickness. Inches.	Loss. Per cent.
American enameled	$\frac{1}{16}$	51.23
Crown	$\frac{1}{8}$	13.08
Crystal plate	$\frac{1}{8}$	8.61
English plate	$\frac{1}{3}$	6.15
Porcelain transparency	$\frac{1}{16}$	97.68
Parisian pink tinge		57
Deep red		80
Window-glass	$\frac{1}{16}$	4.27
Window-glass (green)	$\frac{1}{16}$	81.95
Window-glass (ground)	$\frac{1}{16}$	65.75

The shade is usually supported from the lamp-stem or around the base of the burner by means of a three-branched frame known as a *shade-holder.*

Lamp-stove. One in which the heat is obtained by the burning of oil in wicks beneath the kettle, oven, or what not.

Lamp-wick. The capillary or foraminous material which conducts oil or grease to the part where it is consumed in the flame.

Wicks are usually of woven fiber, — cotton, for instance, — but have been made of muslin, paper-pulp, asbestus, biscuit of fire-clay, etc.

The tubular lamp-wick was made for the Argand lamp, to admit air to the inside of the flame as well as the outside. Wicks are also made flat, to admit air to each side of a flat, comparatively thin flame.

The tubular wick for candles, in imitation of the wick of the Argand lamp, has been patented six times in England. Candle-wicks are also made flat; double, with space between, to bend out in burning; wick woven or wound spirally; plaited wire enclosed in longitudinal threads; woven with asbestus; parallel threads laid longitudinally; wicks coated with various materials, such as resin, stearic acid, silicate of soda, size, glue, oil, or in solution of alum, salts of bismuth, borax, chlorate and nitrate of potash, ammonia, sal ammoniac, acetates of lead or zinc; wicks which bend out of the flame in burning; stationary wicks to which candle is raised; double, triple, compound, and multiple wicks; flat wicks, made hollow by folding around a wire; candles with several small wicks.

Lamp-wick Trim'mer. A pair of scissors or nippers specially designed for cutting off the charred tops of wicks without dropping the snuff.

Lan'cas-ter Gun. A cannon with a twisting, slightly oval bore and conoidal projectile.

Lan'cas-ter Ri'fle. One with an elliptic rifling, the bore being slightly oval in section. The twist is one turn in 32 inches, which is the length of the barrel; bore, .498 inch; eccentricity, .01 in half an inch. The lateral expansion of the bullet causes it to fill the bore. Length of bullet, 2½ diameters with a windage of 4 thousandths, and has a paper patch, — the first of its kind. Named from the inventor.

Lance. 1. (*Weapon.*) A weapon consisting of a long shaft with a sharp point, much used, particularly before the invention of fire-arms. It was the principal weapon of the Macedonian phalanx, and the Roman infantry were armed with it as well as with the *pilum* or javelin.

In the Middle Ages it was held in the highest repute by knights and men-at-arms who formed the main strength of European armies; it was gradually superseded by the invention of gunpowder.

The lance used by knights of the Middle Ages was of a peculiar form. Near the lower end the shaft was

very thick, with a deep opening in which the arm was placed when the lance was put in rest preparatory to a charge. Immediately in front of the opening, the shaft was from a foot to a foot and a half in diameter, and sloped off towards the upper end, which was from a half-inch to three quarters in diameter.

From this weapon the cavalry of the Middle Ages took their name. A *lance* denoted a man-at-arms (horseman completely armed) with four or five attendants. Among the French in the fifteenth century these attendants consisted of three archers, one *coutilier* (so named from the long broad dirk in his belt), and one page or varlet (mod., *valet*). The introduction of fire-arms gradually led to the disuse of the lance in Western Europe, though it continued in use among the Poles, Russians, and other Sclavonic tribes, as well as the Turks, Tartars, and kindred nations. Frederick the Great introduced lancers into the Prussian army, and was soon followed by the Austrians, who term them *Ulans*, and they have been since introduced into all or most of the armies of Europe.

The lances now in use among the European cavalry have a shaft of ash or beech-wood from 8 to 16 feet long, with a steel point 8 or 10 inches long, and to prevent this from being cut off by a saber stroke, the shaft is guarded by a strip of iron on each side from one and a half to two feet long. The other end has an iron cap to prevent splitting. The point has a small pennon, intended to frighten the enemy's horses. When not in use, the lance is carried in a leathern shoe by the right stirrup, dependent by a leathern thong on the right arm. In use, it is carried under the right arm. Their attempted introduction into the American service in the Army of the Potomac was not a success.

2. (*Pyrotechnics.*) Lances are small paper cases, filled with composition, and attached to light frames of wood or bamboo to mark the outlines of the figures in pyrotechnical devices. Various chemicals are used to give the desired color to the flame, viz. : —

For white : 26 niter, 9 sulphur, 5 mealed powder.

For yellow : 8 nitrate of soda, 2 sulphur, 2 mealed powder, 1 lampblack.

For red : 30 nitrate of strontia, 16 niter, 10 sulphur, 7½ mealed powder.

For blue : 4 niter, 1 sulphur, 2 sulphate of copper, ammoniated.

For green : 12 niter, 8 sulphur, 1 lampblack, 24 nitrate of baryta.

3. (*Carpentry.*) A pointed blade, usually employed to sever the grain on each side of the intended path of a *chipping-bit* or *router*.

It is used in *crozes*, *planes*, and *gages* of certain kinds.

Lance-buck'et. (*Cavalry.*) The shoe in which the butt of a lance is carried by the troopers of certain bodies of cavalry.

Lan'cet. 1. (*Surgical.*) An instrument for bleeding.

a, *gum* lancet with three blades of different shapes.

b, *vaccinating* lancet, spear-shaped.

c, needle-pointed vaccinating lancet.

d, *scarificator* for lancing the skin preparatory to cupping.

e, *spring*-lancet for bleeding, consists of a spring, trigger, and blade. The spring is cocked, blade adjusted to the vein, and by pressing the trigger the blade operates instantly. Shown in its pocket-case.

f, *thumb*-lancet, so called from the manner of holding it.

The discovery of minute vessels, termed *lacteals*, which absorb a white liquid, the *chyle*, and pour it into the blood, was made by Aselli, in 1622. Their presence had been noticed by Eristratus in the time of Ptolemy, but their function was not understood. Aselli described them in his *De Venis Lacteis*, Milan, 1627. This work is remarkable as being the first anatomical work illustrated by colored plates. The arteries and veins in red, the lacteals in black.

Fig. 2795.

Lancets.

The smaller circulation of the blood, that from the heart through the lungs and return, was observed by Servetus. He was burnt October 27, 1553, at Geneva, by the order of the city council of Geneva, aided by one who had barely escaped the same fate, and knew better. The pulmonary circulation was distinctly described by Realdus Columbus in his *De Re Anatomica*, published in 1559, and by Andrew Cæsalpinus, who also noticed the refluent motion of the blood in the veins. Sylvius noticed the venal valves. Fabricius, of Acquapendente, noticed that they all opened *towards* the heart.

William Harvey, born in 1578, studied at Cambridge, and under Fabricius at Padua, and made the discovery of the nature of the arterial and venal circulations, and the complete double circulation, in 1616.

Lancets of copper were disinterred in Pompeii in 1819, in the house of a Roman surgeon in the Via Consularis. They were in company with a probe, bullet-hook, catheters, forceps of various kinds, needle, lever for raising depressed bones, cautery, spatulas, etc.

2. (*Metal-working.*) The tapping-bar of a metal furnace.

Lan'cet-arch. (*Masonry.*) An arch with a sharply pointed top. See ARCH.

Lan'cet-win'dow. (*Architecture.*) A high, narrow window terminating in a very pointed arch. It is characteristic of the style of Gothic known as Early English.

Land. 1. (*Milling.*) That part of the face of a millstone which is not furrowed ; that which intervenes between the furrows.

2. (*Agriculture.*) The unplowed portion of a field as distinguished from the furrow and the plowed portion.

3. (*Fire-arms.*) That portion of the bore of a rifle which is not occupied by the grooves.

4. (*Steam-engine.*) The unperforated portion of the face-plate of a slide-valve.

5. (*Nautical.*) The lap of the strakes in a clinch-er-built boat. Also called *landing*.

Lan'dau. (*Vehicle.*) A carriage with a folding

top, called from Landau in Germany, where they were originally made.

Lan-dau-let'. A chariot opening at top.

Land'ing. 1. A pier, wharf, or jetty, for disembarking passengers.

2. The platform of a railway station.

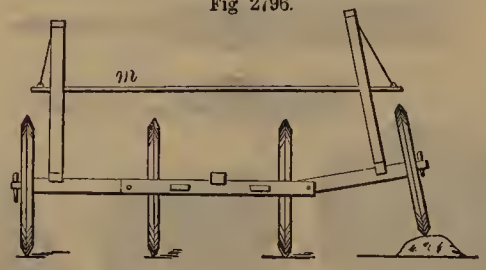
3. The platform of a furnace at the charging hight.

4. A level space at the top of a flight of stairs.

Land'ing-strake. (*Nautical.*) The upper strake but one, of a boat.

Land-mark'er. A machine for laying out rows for planting. In the example, the vehicle has four angular-tired wheels, which are at the required dis-

Fig. 2796.



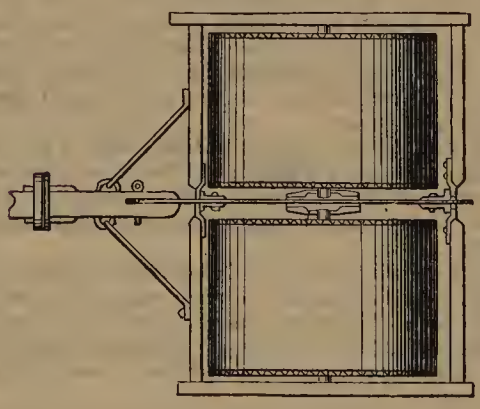
Land-Marker.

tance apart, say 44 to 48 inches, for planting corn, according to latitude and kind of corn. *m* is the driver's seat, supported on posts on the outer sections.

Land-par'ing Ma-chine'. A machine for cutting sods and turfs at a regulated distance beneath the surface. A form of plow.

Land-roll'er. One for leveling ground and mashing clods in getting land into tilth for crops.

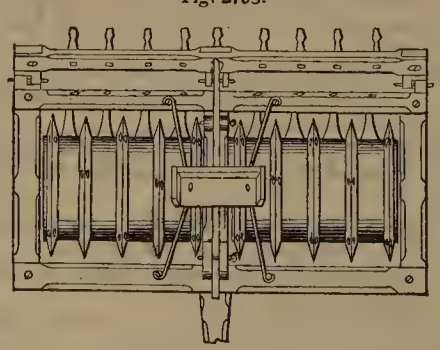
Fig. 2797.



Land-Roller.

In the example, the rollers are so coupled together that they may travel in different planes, and are left free to pass over obstructions independently. The roller in two parts is turned readily, as one may revolve in one direction and the other in the other direction in turning short at the end of a bout.

Fig. 2798.



Land-Roller with Seeder.

Fig. 2798 is a roller with circumferential ridges to break clods, and has a seeding device at the rear.

Land'side. (*Plow.*) The flat side of a plow, towards the land. The lower portion is a bar extending back from the share ; and the upper portion is a plate attached to the sheth and the landside handle.

Land-tie. A rod securing a face-wall to a bank. See PILE.

Lan'gate. A linen roller used in dressing wounds.

Lan'grel. (*Weapon.*) A kind of missile formerly used to destroy the rigging of an enemy's vessel.

It was a cylindrical cage or bundle to fit the bore of the gun, and was filled with bolts, nails, and chunks of iron.

Lan-guet' ; Lan-guette'. 1. (*Music.*) (Fr. *langue*, tongue.) The tongue of a metallic organ-pipe of the mouth or flute kind. It nearly closes the arca of opening in the pipe at a point opposite to the slit, so as to compel the air entering at the lower end of the pipe from the bellows to pass towards the slit which forms the *mouth*. The issuing sheet of air impinges against the metal bounding the upper edge of the slit, so as to divide against the *lip*, and acquire a vibration which is communicated to the column of air in the tube, producing a musical note. See MOUTH-PIPE ; PIPE.

2. A thin *tongue* of metal placed between the blades of a comb-cutter's saw, to preserve their distance.

3. A small piece of metal on a sword-hilt which overhangs the scabbard.

Lan'iard. (*Nautical.*) A cord or line for seizing objects on board ship. See LANYARD.

Lan'tern. 1. A case with transparent sides or panes for holding and protecting a luminous body.

The *hand*-lantern (*a*), *arm*-lantern (*b*), *breast*-lantern (*c*), are named from the modes of carrying them.

Fig. 2899.

Lanterns.

They are known on board ship by their position or duty ; as, *poop*-lantern, *powder-room* lantern, etc.

Perhaps the original lantern is to be found in some varieties of fireflies, in which the phosphorescent light, like Alfred's lantern (A. D. 890), is protected by a horny covering. The ordinary American firefly and the glow-worm have integuments over their little bunches of brilliancy.

Some species of nocturnal moths sail through the dark oceans of night, carrying lanterns at their prows in the shape of eyes, which, black or brown by day, become glowing sparks in the gloom.

It may not be entirely out of place to class some of these natural lights among the "electric lights." Some of them are intermittent, and we suppose them to be urged into brilliancy by what we call a Voltaic impulse from the battery, the brain.

The *dark*-lantern is arranged to display or hide the light, as may be required. It is used by policemen and by burglars.

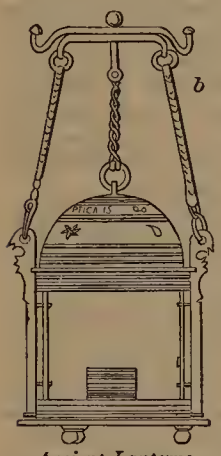
The *magic*-lantern is a mode of displaying pictures, which are made to slide between a light and a lens, their image being thrown upon a screen.

Perhaps the earliest example of a lantern is in a sculpture at Alabastron, Egypt (*a*, Fig. 2800), representing a patrol on its rounds, two soldiers being armed with spears, shields, and battle-axes, and a third one carrying a lantern a little in advance. The panes were probably of talc, the lapis specularius of the Romans.

Fig. 2800.

a

The modern Egyptian lantern consists of a waxed cloth strained over a cylinder of wire rings, and having a top and bottom of perforated copper.



b

Ancient Lanterns.
a, Egyptian; b, Roman.

The mob came out from Jerusalem to search for the Saviour with lanterns and weapons. The moon rose at about 6 P. M. on that night, but it was probably cloudy, or Judas may have suspected that his master would hide in some covert on the mountain.

Lanterns are referred to by the Greek authors: —

"The man who first invented the idea
Of walking out by night with a lantern,
Was very careful not to burn his fingers."

ALEXIS.

"So taking out the candle from his lantern."

Ibid.

"A well-lit horn lantern."

EUMELUS; quoted by ATHENÆUS, A. D. 220.

The lanterns of Epictetus and Diogenes will not be soon forgotten. See also CANDLE.

Lanterns are referred to by the Roman authors Plautus, Martial, and Pliny; have been disinterred at Herculaneum and Pompeii. In the latter place, one was found in the vestibule of a house alongside a skeleton; the person was evidently trying to escape in the thick darkness of the descending ashes. We read of the use of lanterns in the games of the circus, the sacred games of Greece, in augury, and by the military. In the latter case, the Roman soldier carried the lantern on a pike, as did the Egyptian ten centuries previously, and how much anterior to that time we do not know.

The Roman lantern (*laterna*) was usually of bronze, with panes of bladder, horn, mica, parchment, oiled silk, or sometimes, under the emperors, of glass.

One is shown at *b*, Fig. 2800. It is cylindrical. The bottom plate has three balls for feet, and three posts for suspension. The metal is bronze. Within is a lamp of the same metal. The interior was reached by raising the hemispherical cover.

A great ship-lantern hanging by the poop of a vessel appears on Trajan's column.

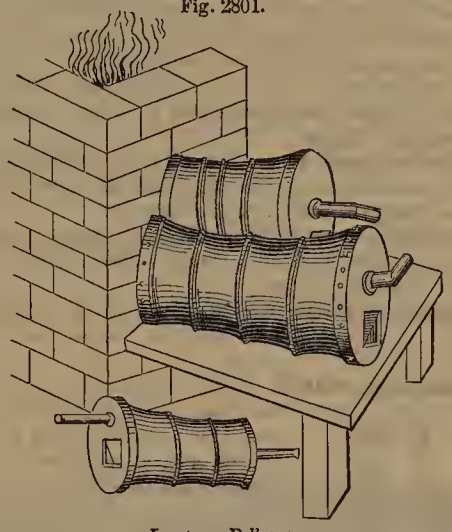
Alfred the Great had a horn lantern around the graduated candle which was his time-measurer.

2. The light-chamber on top of a lamp-post.

3. The upper member of a lighthouse containing the light.

4. (*Architecture.*) A small cupola or dome-topped structure on a roof or tower. A *tholus*. The tholus of the United States Capitol is illuminated by a cluster of burners lighted by electricity from the level of the rotunda floor, 264 feet below.

Fig. 2801.



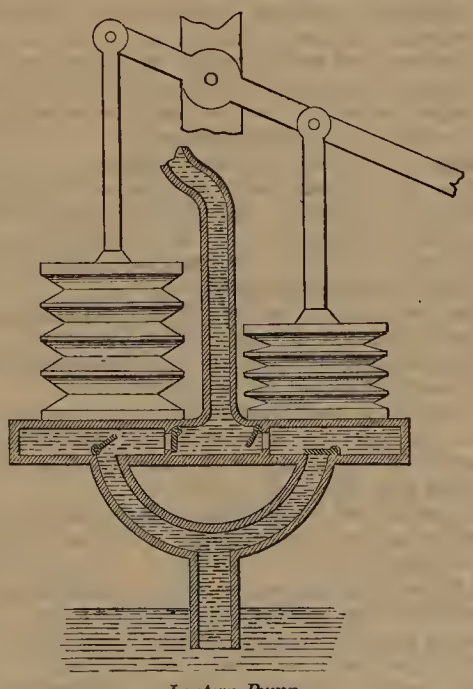
Lantern-Bellows.

5. A trundle-wheel. A *wallower*. See LANTERN-WHEEL.

6. (*Calico-printing.*) A certain description of apparatus by which steam is applied to cloths in order to fix the colors with which they have been printed. The colors consist of a mixture of dye-extracts and mordants. The lantern has a frame with tenter-hooks, from which the cloth is suspended in a zigzag manner; and a penthouse, with a pyramidal roof encloses the frame and cloth, shutting in the steam around them.

7. (*Founding.*) A hollow, perforated core of large diameter relatively to its length.

Fig. 2802



Lantern-Pump.

Lan'tern-bel'lows. So called from its resemblance to a paper lantern.

Air is admitted through an inwardly opening valve at the outer end of the bellows in the action of drawing it out, and expelled by pushing it in by means of the handles operated (in the example) by the right and left hands of the workman, their alternate action causing a continuous blast. They may be arranged to be operated by the feet. This apparatus is of great antiquity, and is still in general use in Asia and Egypt.

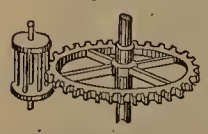
Lan'tern-pin'ion. A pinion of rundles between disks mashing into the cog-wheel of some kinds of horse-powers. See LANTERN-WHEEL.

Lan'tern-pump. One having a pair of disks at the ends of a flexible cylinder, like a Chinese lantern. See BAG-PUMP.

Lan'tern Stuff'ing-box. A long stuffing-box with tightening bolts, used in some marine-engines.

Lan'tern-wheel. This is allied to the cog-wheel, the bars or spindles which connect the parallel heads being so spaced and proportioned as to engage with the cogs of the spur-wheel. It is a cheap form of wheel, and is seldom used where facilities are at hand for making better. It bears the relation of a pinion to the spur-wheel. It is sometimes called a *wallower* or *trundle* wheel, from the *trundles* or rundles of which it is made.

Fig. 2803.



Lantern-Wheel.

Lan'yard; Lan'iard. (*Nautical.*) A cord, line, gasket, or sennit, for seizing or lashing objects on board ship; as, —

The rope which passes through the *dead-eyes, hearts,* or *thimbles,* used in setting up *shrouds* or *stays.*

The lanyards of the cat-hook; the *fish-tackle.*

The lanyards of the buoy; the *lashing.*

The lanyards of stoppers, etc.

A lashing for securing the gun-ports; fastening spars in their *beckets*; boats to the ring-bolts on deck; the *hatches* to the *coamings;* the binnacle in its place; suspending the hammocks from the hooks of the deck-beams.

(*Ordnance.*) A strong, double-twisted twine about 2 inches in diameter, 12 feet long, and having a hook at one end and a toggle at the other. It is used to pull the trigger of the gun-lock of a piece of ordnance, or to jerk the friction tube, according to the modern plan of firing cannon.

Lap. 1. (*Grinding and Polishing.*) A wheel, disk, or piece of soft metal used to hold a polishing powder, as in cutting and polishing gems. Hence the term "*lapidary's* art." It is usually a rotating wheel on a vertical or horizontal axis, with a working face or periphery respectively.

Laps are made of various metals and alloys, such as *brass, cast-iron, copper, lead,* and *pewter.*

Brass is used by opticians with emery and water, for smoothing lenses and speculums.

Cast-iron is used with sand or emery in many trades; by glass-grinders, opticians, etc. The cast-iron *lap* of the lapidary is called a *skive,* and is charged with diamond-powder.

Copper is used by machinists, by lapidaries, glass-grinders, and glass-engravers. It is usually charged with emery.

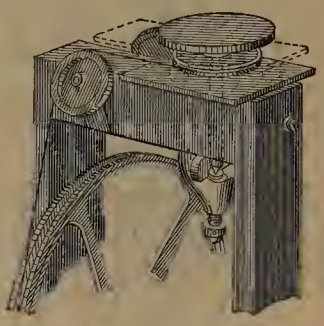
Lead and its alloys are used by machinists, cutlers, lapidaries, jewelers, watchmakers, etc. It is charged with emery, rottenstone, crocus, etc.

Tin, zinc, and their alloys are also used.

The powder in either case is burnished into the metal, the latter merely forming a vehicle for the abradant or polishing-powder.

Lead *laps* sometimes consist of a disk of metal, secured by a screw-nut against a shoulder on the spindle, but are better cast upon a perforated iron plate, which gives rigidity to the *lap,* while the soft lead or pewter allows the grinding-powder to be imbedded therein.

Fig. 2804.



Horizontal Lap.

Some adopt a disk of wood with a leaden tire cast around it.

The cutler's *lap* is cylindrical, and has a wooden center made in several pieces, the grain of the wood presented outwardly, and the disks of which it is composed fastened by circular plates at the ends. The wooden center is turned to the required width, and has a groove in the middle of the face and chamfers at the edges to hold the metallic rim which is cast thereon. This is composed of tin 1, and lead 4 or 5 parts. The edge is then turned true, and is prepared for use by a dressing of emery and oil. Also known as a *glazer.*

This wheel may be used for grinding or polishing, by having regard to the kind of emery, the degree of pressure, and the mode of holding the article. See GRINDING-MATERIALS.

2. (*Steam-engine.*) *a.* Lap of the slide-valve on the steam side is the space which it advances beyond the opening of the steam-port after it has closed it, and is given for the purpose of causing the engine to work expansively, by cutting off the admission of steam before the end of the stroke. *Inside lap.*

b. Lap on the exhausting side of the piston causes the passage to the condenser to be closed before the end of the stroke, the piston being then said to be *cushioned* by the elasticity of the confined vapor upon which it descends. *Outside lap.*

3. A plate covering the line of junction of two iron plates which make a *flush-joint,* and to which they are both connected by solder or lines of rivets. See CARVEL-BUILD.

The usual lap of iron plates in ships is from 5 to 6 diameters at double-riveted joints, and about 3 diameters at single-riveted joints.

4. (*Roofing.*) The distance which the tail of a shingle or slate overlaps the head of the second course below. The overlap on the course immediately below is the *cover.* The exposed portion is the *margin;* the width of the *margin* is the *gage.* The *gage* with shingles is about one third of the length, so that two thirds is *cover.* The *gage* of slates is something under one half the length. The excess over twice the *gage* is the *lap* or *bond.*

5. (*Masonry.*) The overlay of a stone in a wall on its bedstone.

6. (*Fiber.*) A layer or continuous band of cotton fiber made into *batting,* and wound or lapped upon an axis or roller ready for carding.

The sheet of cotton as it enters the carding-machine. As it comes therefrom it is called the *fleece.*

Lap'ar-a-tome. An instrument for performing laporotomy, or cutting into the abdomen in the region of the loins.

Lap-board. (*Tailoring.*) A board resting on the lap and hollowed out on the side next the user. Employed by tailors and seamstresses to cut out work upon.

Lap-dove'tail. (*Joinery.*) A form of *secret* or concealed dovetailing, which shows the thickness of the lap only on the return edge, where it has the appearance of a thin board. See DOVETAIL.

Lap-frame. (*Flax-manufacture.*) A machine in which several slivers of carded tow from the *breaker*, or first carding-machine, are united in a lap and wound on a bobbin, from which they may be fed to the *finisher*-card.

Lap'i-da-ry-mill. The grinding and polishing apparatus of the lapidary. See LAPIDARY-WHEEL; LAP.

Lap'i-da-ry-wheel. The art of diamond-cutting was probably known in China and India at an early day, but the stone was little known among the ancients of Europe and Western Asia. Other varieties of stones were mounted and used in great numbers. Pliny refers to gem-cutting: "How many hands are worn down that one little joint of our finger may be ornamented." The Arabians brought the diamond into notice. The discovery of the Brazilian mines in 1730 made it more common. Berghen of Bruges furnished the lapidaries' wheel with diamond-dust, enabling him to cut diamonds, as other stones were cut by the emery previously used. Diamonds were previously set in the rough. They are now cut into *brilliants* or *rose-diamonds*. See BRILLIANT; DIAMOND.

The plano-convex lens of rock-crystal found at Nimroud by Layard showed the marks of the lapidary's wheel. The seals of this wonderful nation required the lap to reduce them to form. They were of various hard materials, such as amethyst, agate, etc., gems and semi-gems. See SEAL.

The wheels of the lapidary are of two kinds.

The *slicer*, which is a thin iron wheel touched with diamond-dust, and used like a circular saw.

The *lap* or horizontal wheel, called a *mill*, whose flat face is touched with materials of a hardness adapted to the subject and to the stage of the work.

The operations are called *cutting*, *grinding*, or *polishing*.

The *mills* are known as *slitting*, *roughing*, *smoothing*, or *polishing*.

The materials of the *mills* are *iron*, *lead*, *tin*, *willow*, *mahogany*, or of wood covered with *list* or *leather*.

The abrading materials are *diamond-dust*, *sapphire*, *ruby*, *corundum*, *emery*, *rottenstone*, etc.

Slicing by a circular saw or *splitting* in the lines of natural cleavage are resorted to when admissible.

The *slitting*-wheel is usually of *iron* touched with *diamond-dust*.

The *grinding*-wheel is usually of *lead* touched with *emery*.

The *polishing*-wheel of tin touched with rottenstone. See DIAMOND-CUTTING.

Fig. 2805 is a view of the lapidary's bench, showing the crank, the driving-wheel, the lap, and the *gim-peg*, which latter has holes in which rest the upper end of the *dopp*, on which the gem is cemented to be applied to the lap. The choice of holes determines the inclination of the *dopp*, and consequently the angle of the facet.

Carnelian, as an example, is first slit with the thin iron slicer, fed with diamond-dust, and moistened with brick oil; secondly, it is rough ground on the lead-mill with coarse emery and water; and, thirdly, it is smoothed either on the same lap rubbed down fine, or with a similar lap used with finer emery.

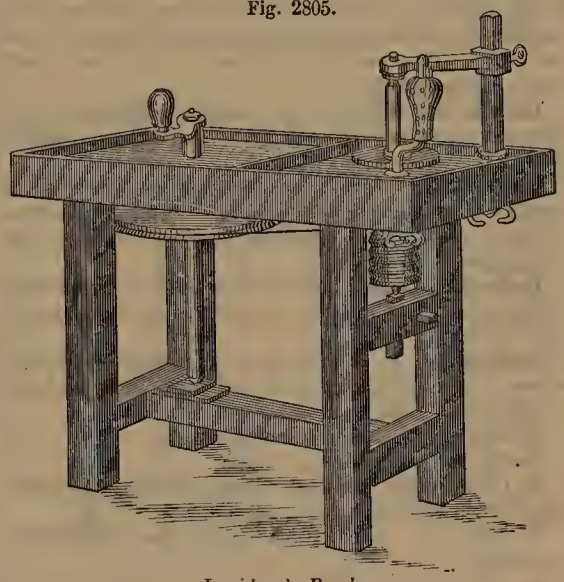
Carnelian, and stones of similar or superior hardness, which are not smaller than about one third of an inch in diameter, are polished on a lead-mill supplied with rottenstone and water. The face of the polishing-lap is *hacked* or *jarred*, to enable the powder to adhere. This *hacking* is done by holding a knife in a slanting position, so as to *chatter* upon the revolving lap and make small furrows therein, which hold the powder.

Smaller and harder stones are polished on a pewter lap, and still harder upon a copper lap.

Rounded stones, said to be cut *en cabochon*, are wrought by means of the *wooden-mill* with fine emery, the *list-mill* with pumice-stone, and *leather-lap* with putty-powder.

Faceted work on pastes and artificial stones, also carnelians, amber, jet, etc., are cut on lead-wheels with emery and polished on pewter with rottenstone. Gems of a somewhat harder kind use a pewter lap and fine emery for the cutting, and a copper lap with rottenstone for the polishing. For sapphires, the

Fig. 2805.



Lapidary's Bench.

chrysoberyl, and some few other stones, a copper lap with diamond-powder is used for cutting the facets, and a copper lap with rottenstone for polishing them. Lastly, for the diamond, two stones are rubbed in a peculiar manner, the one against the other, to start the facets, and they are cut and polished by means of an *iron* lap or *skive* fed with diamond-powder, being cemented on a *dopp* and held upon the *lap* by means of a *gim-peg*, as above described. See also DIAMOND-CUTTING.

Substances treated by the lapidary like carnelian: agate, amethyst, aquamarine, beryl, blood-stone, Brazilian topaz, carbuncle, cat's-eye, chalcedony, chrysolite, chrysoprase, crystal, elvans, emerald, feldspar, flint, fluor-spar, garnet, granite, heliotrope, jade, jaspar, lapis-lazuli, marble, mina nova, onyx, opal, pastes, peridot, plasma, porphyry, quartz, sard, sardonyx, serpentine, topaz. See Feuchtwanger's "Popular Treatise on Gems."

La-pid'e-on. A musical instrument contrived by M. Baudry, made of flints and schist suspended from an iron frame, and struck with a flint hammer to produce the notes. The flints are about forty in number and elongated, but of various lengths and thicknesses. They are arranged in the order of their tone, and the labor and investigation of years were required before the complete scale was formed.

A correspondent of "Nature" writes that in roaming over the hills and rocks in the neighborhood of Kendal, near Lancaster, England, which are

composed chiefly of limestone, he had often found what are called "musical stones." They are generally thin, flat, weather-beaten stones, of different sizes and peculiar shapes, which, when struck with a piece of iron or another stone, produce a musical tone instead of the dull, heavy, leaden sound of an ordinary stone. The sound of these stones is in general very much alike, but sets of eight stones have been collected which produce when struck a distinct octave. The new French scientific weekly, "La Nature," copies the communication from its English namesake, and brings forward some additional instances of the same phenomenon. It tells of a performer who played musical airs on rough flints suspended by silk threads, striking them with an iron rod. We are also informed of the accidental discovery of musical properties in a stone fountain at the French Institute. A distinguished musician, A. Elwart, having struck it with the palm of his hand, elicited "a musical sound corresponding with extreme precision to the perfect accord major of *fa* natural." The fountain in question is in the grand court of the Institute.

La'pis-laz'u-li. A rare ornamental stone of a deep blue spotted with a deeper blue, and intermixed with a few grains of gold.

Lap-joint. One layer overlapping the edge of another; as the *clincher*-build of boats. Illustrations are also found in *halving*, *scarfing*, and *cauking* of timbers (which see).

Lap-ma-chine'. (*Spinning.*) A *spreader*, *spreading-machine*, *blower and spreader*. See LAPPING-MACHINE.

Lap'ping. 1. Grinding or polishing on wheels whose metallic rims are provided with emery and oil.

Glazing is done on wooden wheels.

Polishing on leather-covered wheels.

Buffing on leather, with rouge.

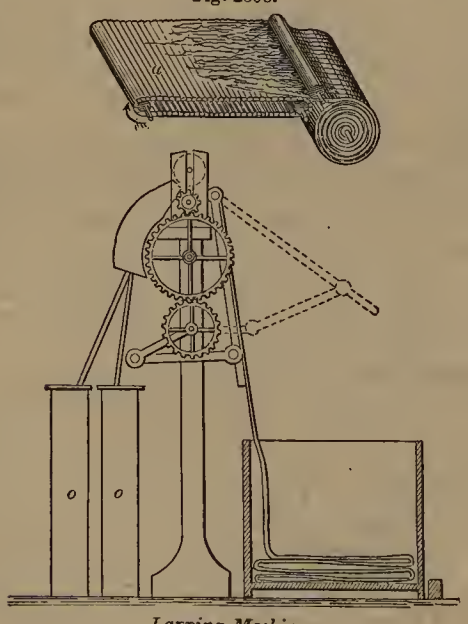
2. (*Spinning.*) Laying several fleeces or slivers together. See LAPPING-MACHINE.

3. (*Fabric.*) A machine blanket used by calico-printers.

4. (*Ordnance.*) Wearing away the land surface in a rifled gun to ease the entrance of the projectile.

Lap'ping-ma-chine'. (*Cotton Manufacture.*) *a.* A machine in which cotton is reduced to a downy condition, spread equally, subjected to a certain compacting pressure, and then wound in an even continuous wad (*wadding*) upon a roller, forming a *lap*.

Fig. 2806.



Lapping-Machines.

Prepared cotton may be spread upon the traveling apron *a*, in weighed quantities, covering a marked area, as between occasional black slats; or it may be formed into a *lap*, after a succession of scutching and blowing operations. See BATTING-MACHINE.

b. After cotton has undergone a preliminary carding in the *breaker*, from which it comes in the form of a thin fleece, several of these fleeces are joined to form one thickness.

In another form of *lapping-machine*, several cans *o o*, filled with a narrow fleece from the breaker-card, are placed in two rows, and the ends of the fleeces brought together between two rollers, the lower one driven by a wheel and pinion and the upper one pressed down upon the former by weights.

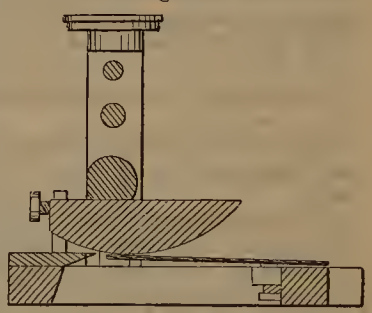
Lap-ring. An open ring in which the ends lap past each other without touching, so that it may form a connecting link for attaching the single-tree to the *clip* of the *double-tree*, or connecting the ends of a broken chain, etc. A *cotter* is a better device for the latter purpose, however. (See COTTER.) The *lap-ring* is somewhat like a *split-ring*, but the latter is elastic. The heavy material of the *lap-ring* precludes elasticity.

Lap-roll'er. (*Fiber.*) One in a lapping-machine, upon which the fleece or wadding is wound.

Lap-shav'er. A machine for shaving leather to a thickness by means of a knife set to a graduated distance from a roller or an edge over which the hide or piece of leather is passed. The term is derived from the old practice of shaving away inequalities by means of a knife while the leather laid upon a board in the lap.

Lap Skiv'ing-ma-chine'. A machine for scarfing off the thickness of leather towards the edge. In Fig. 2807, as the strap is drawn across the edge of the knife, the eccentric gage-block swings on its bearing and gradually descends, tapering the strap toward the end. Each part is adjustable to vary the operation within given limits.

Fig. 2807.



Skiving-Machine.

Lap-stone. A stone laid in the lap, and used as an anvil by a shoemaker in hammering his leather.

Lap-streak. A structure, usually in boats, in which each streak or plank *laps* over the one below it. *Clincher-built.*

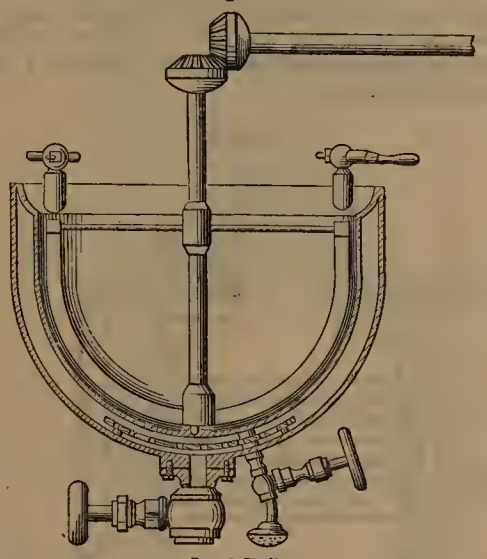
Lap-weld. (*Forging.*) A weld in which the welding edges are thinned down, lapped, and welded.

Lar'board. (*Nautical.*) The left side of a vessel to a person standing on deck and facing toward the bow. From the Italian *quella borda*, that side; in contradistinction to *questa borda*, this side; abbreviated into *la borda* and *sta borda*. *Port* is now substituted for larboard, to give a greater difference in the sound of the word of command.

Lard-boil'er. A steam-heated pan in which the fat of hogs is boiled, to obtain the lard by the shrinkage and hardening of the membranes. In the example, the hemispherical boiler has double walls, with openings for the inlet of steam, the discharge of air

and condensed water, and an exit opening, with a strainer for the lard. Stirrers revolve within the

Fig. 2808.

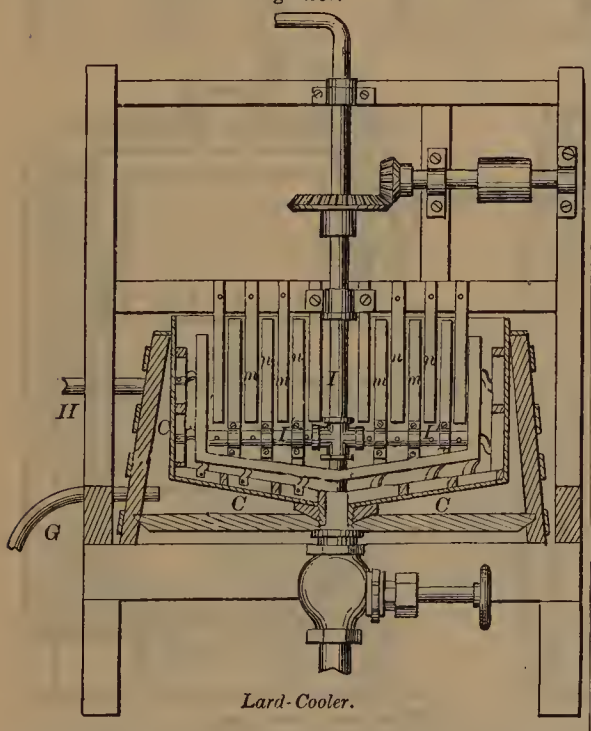


Lard-Boiler.

pan, and a perforated plate above the steam inlet distributes the steam upon the bottom of the pan. See also LARD-RENDERER; LARD-TANK.

Lard-cool'er. One in which rendered lard is artificially cooled. The inner vessel containing the lard is surrounded by a space *C* to be filled with cold water, passed in and out through pipes *H G*. Air is forced through a tubular shaft *I* into the inner vessel. Wooden scrapers prevent the cooled lard

Fig. 2809.

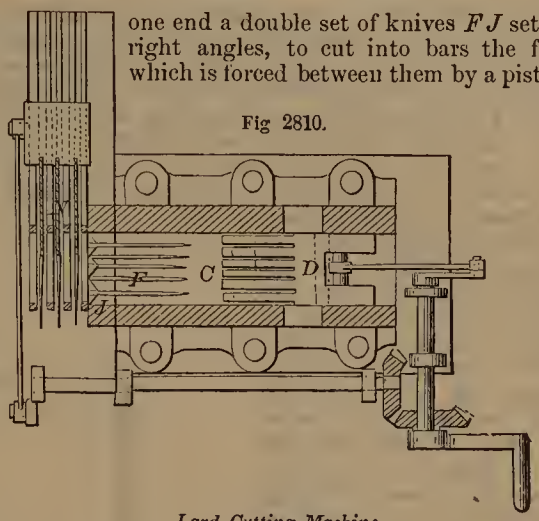


Lard-Cooler.

from accumulating on the sides of the vessel. Movable wooden slats *m* pass between fixed ones *n* to agitate the liquid contents of the inner vessel.

Lard-cut'ter. One for cutting lard for rendering. This is usually performed by knives at a bench; but, in the example, a close trough *C* has at one end a double set of knives *F J* set at right angles, to cut into bars the fat, which is forced between them by a piston

Fig 2810.



Lard-Cutting Machine.

D. The bars are then cut into short pieces by knives *N* reciprocated transversely to the trough.

Lard-press. A press in which cooked lard is pressed from the cracklings.

Fig 2811.

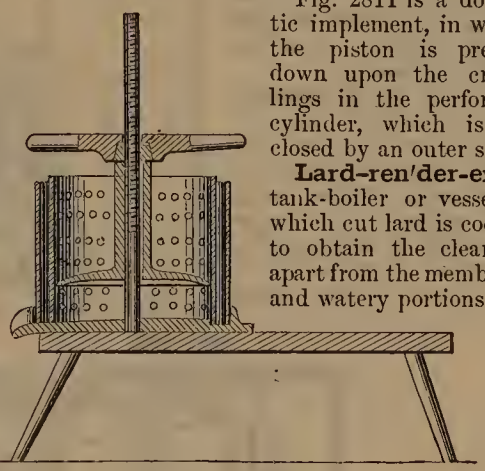


Fig. 2811 is a domestic implement, in which the piston is pressed down upon the cracklings in the perforated cylinder, which is inclosed by an outer shell.

Domestic Lard-Press.

Lard-ren'der-er. A tank-boiler or vessel in which cut lard is cooked to obtain the clear fat apart from the membrane and watery portions.

Lard-tank. A vat in which fats are cooked to obtain them free from watery matters and membrane.

Wilson's tank is a vertical cylinder with a charging hole at top; a steam-jacket and steam-coil for heating; try-cocks at different hights for examination of contents; discharge-cocks at different hights for drawing off the liquid oil and the water; discharge-hole, with cover at the bottom, to remove the solid matter from the bones and fibrine.

In Everett's apparatus (Fig. 2812) the digester, containing the fat, is surrounded by an outer shell constituting a hot-water and steam space, to which it is connected by stay-rods, which unite the water-space at bottom with the steam-space at top, and pass through the vertical flues *A B*. The vapors from the digester, charged with odors and organic matter, pass through a pipe at top of the apparatus into a super-heating coil over a furnace, into which they are finally discharged and consumed. A spiral flue surrounds the outer case of the boiler.

Broadnax's apparatus consists of an exterior casing of masonry in which the digester, which may be of the form shown either in the upper or lower figure, is placed. In the first it is stationary, and consists of an inner and outer shell, between which

and through flues in the inner one *A A* the heat circulates. The rendered fat, in a fluid condition, descends from shelf to shelf, and is strained through the perforated bottom *C*, whence it is drawn off. The furnace has an inclined flue at each side, through which the products of combustion pass to and around the digester. Gases from the digester are delivered into the furnace. This may be effected, as shown in the first figure, by an air-pump *J* and condenser *K*, by which the gases withdrawn from the digester are compelled to pass through a cylinder, heated by a grate *P*, in which the watery particles are condensed by a series of plates *i j* and drawn off by a pipe; the dry vapor, ascending, passes through another pipe to assist in heating the furnace.

In the lower figure, the perforated digester *G* is mounted on trunnions and rotated by a crank; the oil exuding is strained through the diaphragm *E*, and the gases pass through the pipe *I* to the furnace. *H* is the charging manhole.

Large-face Lathe. (*Wood-working.*) A lathe for turning patterns of wheels, heavy moldings, and other large circular work. It has a hinged tool-rest on a bracket, which may be moved out of the way to allow the work to swing to the floor if necessary; or even larger work may be done by preparing a pit for the object to swing in.

Fig. 2813.

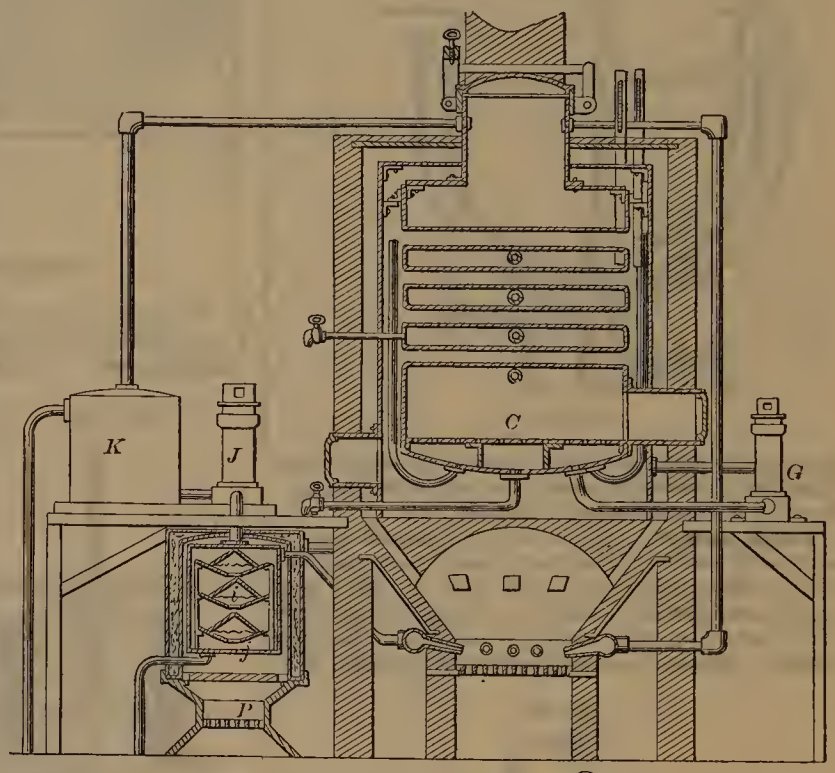
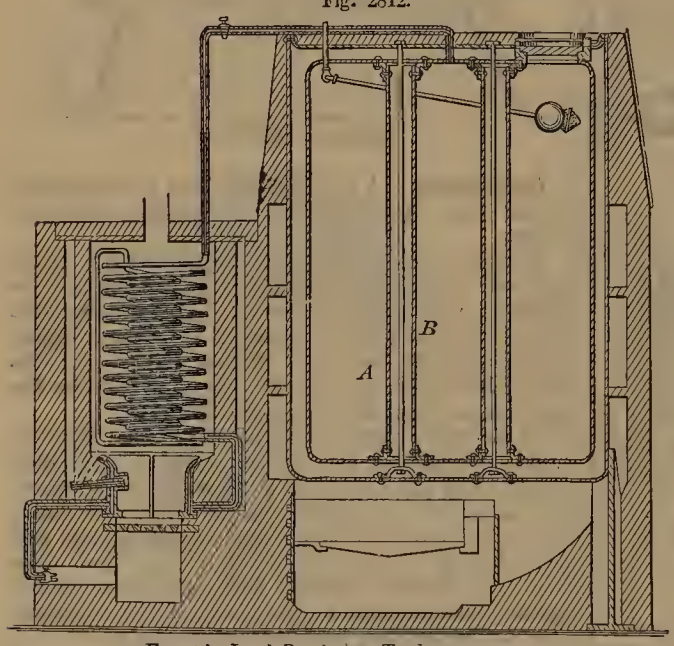
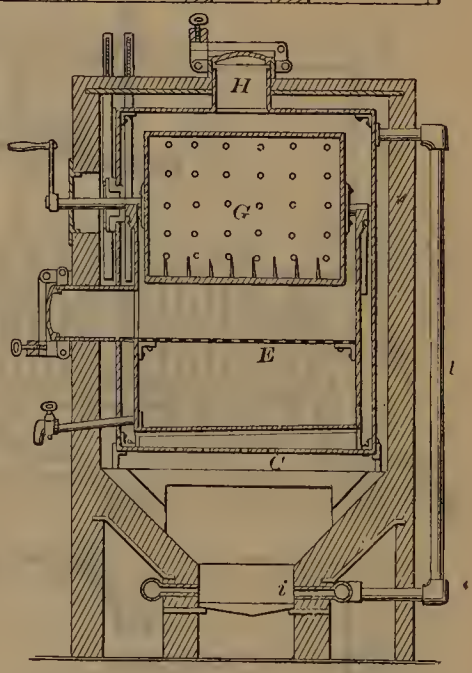


Fig. 2812.



Everett's Lard-Rendering Tank.



Broadnax's Lard-Tank.

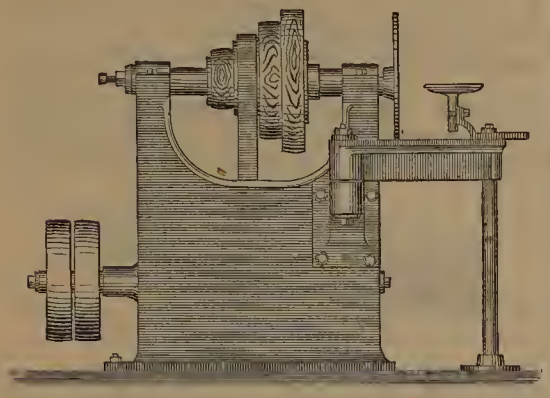
Lar'get. A piece of bar-iron, cut off to a length (and weighing say about 14 pounds for an average sheet), forming a blank to be heated and rolled into a sheet of iron. (English Spec. 14,244.) It is to the *sheet* what the *loop* is to the *bloom*, the *fagot* or *ball* to the *bar*.

Lar'i-at. A rope 1¼ inches in circumference and 30 feet long, used for picketing horses in camp. It is fastened to a ring on the picket-pin, which is driven into the ground, permitting the horse a limited circle to graze in.

Lar'mi-er. (*Architecture.*) The corona or dripstone of a doorway or window-way.

Lar'yn-ge'al E-cra'seur. (*Surgical.*) An instrument for extirpating abnormal growths of the larynx and epiglottis. It consists of a steel rod,

Fig. 2814.



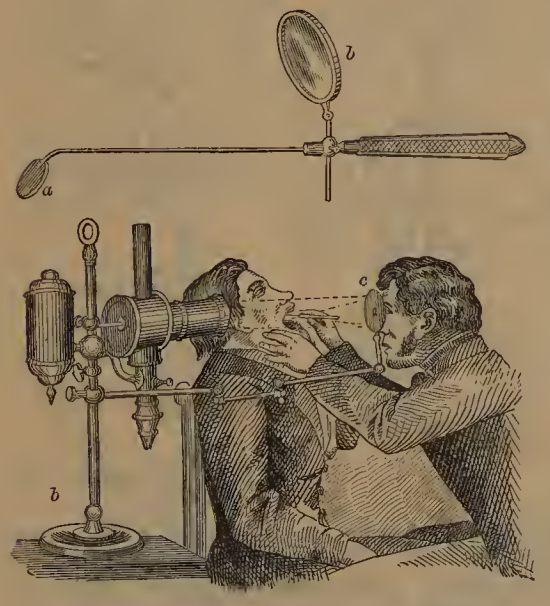
Large-Face Lathe.

about 8 inches long, curved, and fenestrated at one extremity. A wire loop is first passed around the object to be extirpated, is drawn through the fenestrum *slowly*, by means of either a screw or lever at the other end of the instrument, thus *crushing* it off.

By this method (ecrasion) the loss of blood is avoided.

La-ryn'go-scope. An instrument for obtaining a view of the larynx. It consists of a small plane mirror *a* on a long, slender stem, which is introduced to the back of the throat, and a *large* concave mirror *b* for reflecting light (solar or artificial). This last reflector may be either fixed to a stand or suspended from the forehead of the operator. An *inverted* image is seen in the *small* mirror. The upper figure is Elsberg's laryngoscope. When artificial light is employed, the patient should sit so that it is a little back of him and on his right side, as in Tieman's instrument (the lower figure). In this case, the light is reflected by a concave mirror *c* to

Fig. 2815.



Elsberg's and Tieman's Laryngoscopes.

the smaller mirror, which is held by the observer at the posterior part of the mouth, the uvula resting upon its back. By its means, the vocal chords of the interior of the larynx are exhibited, and have been photographed. One constructed by Dr. Turck in 1857 was modified and improved by Dr. Czermack of Pesth, 1856, who exhibited it in action in 1862, in London. Mr. John Avery of London is said to have constructed a similar apparatus in 1846.

La-ryn'go-tome. Laryngotomy, or the opening of the larynx, was practiced by the ancients in quinsey. It was recommended by the Greek and Arabian physicians, by Galen and Asclepiades decidedly.

Lash. 1. (*Weaving.*) A thong formed of the combined ends of the cords by which a certain set of yarns are raised in the process of weaving Brussels carpet. Each yarn (termed an *end*) passes through an eye (the *mail*), to which is attached a cord passing over a pulley above the frame of the loom. The cords required to raise to the surface a certain set of yarns, required for one row in the pattern, are bound together into a lash, so as to be operated by a single pull. See Brussels Carpet.

2. The thong or braided cord of a whip.

Lash'er. (*Nautical.*) The rope which binds a gun to the rings at the check of the port.

Lash'ing. (*Nautical.*) A rope or gasket, by which anything is secured on board ship, by wrapping around it.

Fig. 2816.

Lashing.

As the *lashing* of a studding-sail boom.

The lashing of the parts of a ponton-bridge.

The lashing at the head of a *shears*.

The lashing of a tail-block.

Also the act of binding one thing to another.

Las'ket. (*Nautical.*) One of the rings of cord on the head of a *bonnet* or *drabbler* to secure it to the foot of the sail above, by a lacing cord. A *latch*.

Lasque. (*Diamond-cutting.*) A kind of table diamond. See "Jeffries on the Diamond."

Las'so. A rope with a running noose, used in Spanish America and Texas for catching cattle, etc.

In the British cavalry, 10 men per troop are furnished with a *lasso*, not as a weapon, but that they may aid in drawing a load on emergencies.

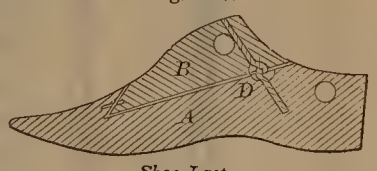
The lasso was used in war by the ancient Egyptians, as we see by the paintings at Thebes.

The Sagartians, a cavalry contingent of the army of Xerxes, used "lassoes which end in a noose." — Herodotus, VII. 85.

The lasso is seen in the sculptures upon the palace of Asshur-bani-pal, a son of Esarhaddon, which are now in the British Museum. Pausanias states that the Sarmatians used it; Suidas, that it was used by the Parthians. To this list may be added the Huns, the Alani, and among moderns the Pampas Indians of South America.

Last. A foot-shaped block *A B* placed inside a shoe, to give shape to the upper and hold the parts, which are tacked thereto previous to pegging.

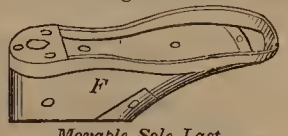
Fig. 2817.



Shoe-Last.

F is a last, shown side up, to expose the sole, which has a metallic rim around the edge to hold a wooden sole, which may be replaced when worn out.

Fig 2818.

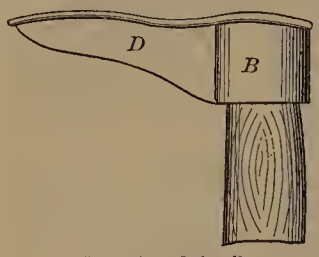


Movable Sole-Last.

D B is a metallic foot-shaped anvil for holding boots and shoes while clinching nails.

Lasts are mentioned by

Fig. 2819.



Last-shaped Anvil.

the Greek authors. Right and left lasts were introduced in England about 1785.

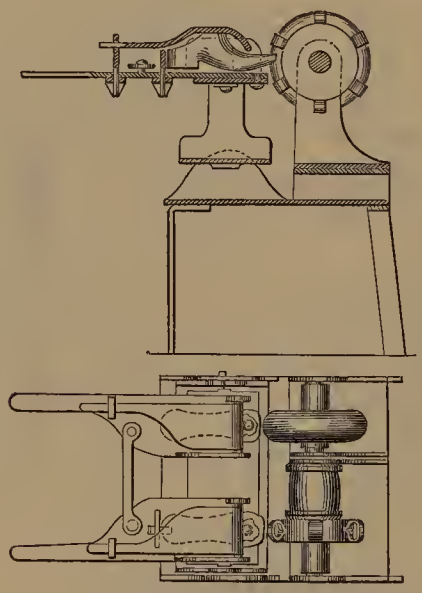
Last'age. (*Nautical.*) Ballast or lading in a ship.

Last'er. A tool for stretching the upper leather over a last. See LASTING-TOOL.

Last-fin'ish-ing Ma-chine'. A machine in which the ends of lasts, which are held in the chucks of a last-turning machine, are dressed up and finished.

Fig. 2820 shows a lathe having a revolving cutter

Fig. 2820.

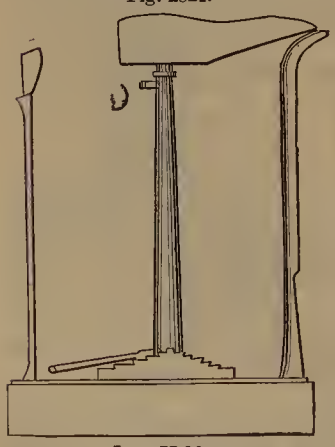


Last-Finishing Machine.

to operate upon the last at the same time and in the same direction that the guide-wheel presses upon the pattern. The supporting frame is on the pantograph principle, and any change in the position or form of the model is reproduced in the last.

Last-hold'er. (*Shoemaking.*) A standard for the last while lasting, pegging, sewing, soleing, etc.

Fig. 2821.



Last-Holder.

The last is placed upon a standard rotated by a lever, to bring the toe of the boot against the rest-standard at either end of the base. One standard gives an upward support for pegging, and the other a side support for sewing. The lever is held by a ratchet.

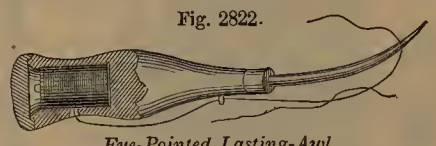
Last'ing. 1. (*Fabric.*) *a.* A five-leaf twill stuff; a stiff woolen fabric in which horsehair was formerly interwoven to form a stiffening for stocks or dresses.

b. A woolen fabric used in making women's shoes.

2. (*Shoemaking.*) The process of drawing the upper leather smoothly over the last.

Last'ing-awl. A sewing awl for shoe-closers. The example shows one carrying a bobbin in the handle of the awl, leading the thread out through a hole in the handle, and passing it through an eye in the point of the awl. In use, the awl, being passed

Fig. 2822.



Eye-Pointed Lasting-Awl.

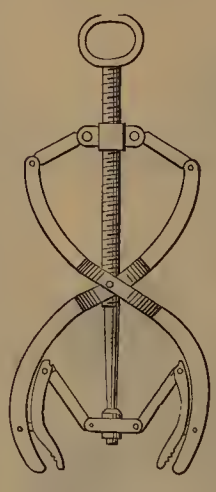
through the leather, carries with it the thread; then being slightly drawn back, it forms a loop through which a second thread is passed. The entire withdrawal of the awl then makes a lock-stitch, similar to that made on some sewing-machines.

Last'ing-jack. An implement to hold the last while straining and securing the upper thereon; and for centering or adjusting the insole and outsole for the subsequent action of the pegging or sewing-machine. Sometimes used in hand-pegging.

Last'ing-ma-chine'. (*Shoemaking.*) A device for drawing the upper leather of a boot or shoe smoothly over the last, turning the projecting edges down upon the insole, and holding them until they are properly secured by tacks or other fastenings.

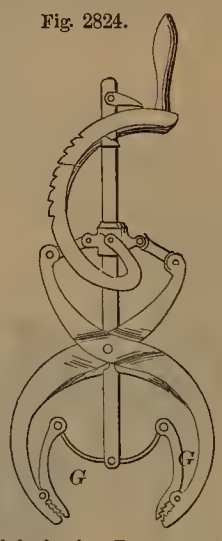
Last'ing-pinch'ers. (*Shoemaking.*) A tool to grip the edges of the upper leather of a boot and draw it over the last. The two jaws are gripped simultaneously upon the edges of the leather, by the motion of the nut *C* upon the screw, and the same movement brings the jaws toward each other and stretches the leather around the last.

Fig. 2823.



Lasting-Pinchers.

Fig. 2824.



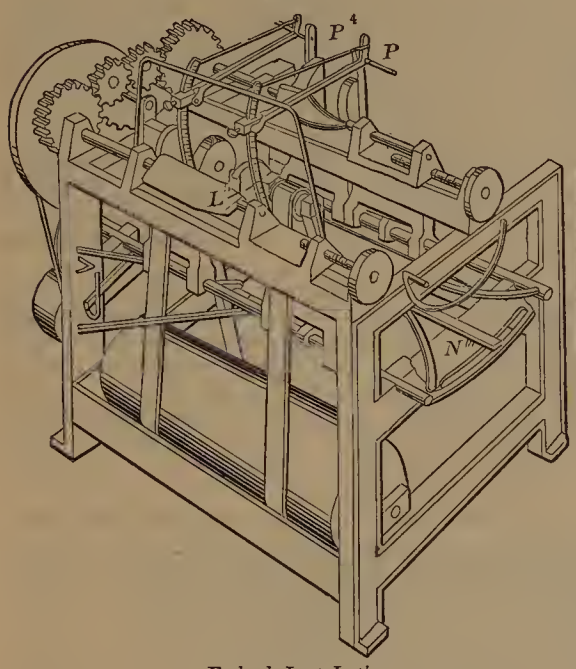
Tool for lasting Boots and Shoes.

Last'ing-tool. (*Shoemaking.*) A tool for gripping the edges of an upper leather and straining it over a last. In the example, the two pairs of jaws *G G* engage the sides of the leather, being drawn thereupon and inward simultaneously, by the action of the cam lever.

Last-mak'ing Ma-chine'. (*Wood-working.*) A machine for cutting lasts from the block or blank. The work is usually done in a LATHE FOR TURNING IRREGULAR FORMS (which see).

Such is also the machine (Fig. 2825) in which, by a train of gearing, the block L^5, from which the last

Fig. 2825.



Frohock Last-Lathe.

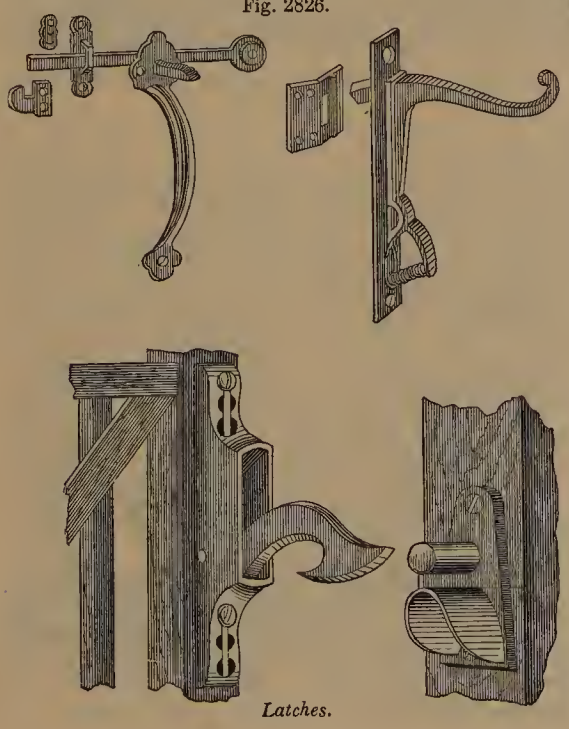
is to be cut, is made to present a face to the cutters precisely corresponding to the face of the model against guides on rods P P^4. By moving links on these rods up or down on their graduated scales, the last may be enlarged or reduced in its relative proportions to the model. A similar variation of the bar N''' on the sector at the end of the machine will vary the work in relation to its length as compared with the model.

Last-turn'ing Ma-chine'. See LATHE FOR TURNING IRREGULAR FORMS.

Latch. 1. (*Hardware.*) A door-fastening, consisting of hinge-bolt and catch. A latch may be opened from either side of the door or gate.

Latches are known by purpose, or peculiarity of construction, as —

Fig. 2826.



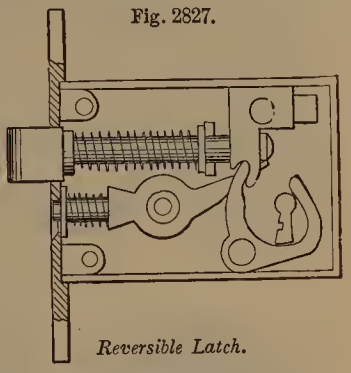
Latches.

Rim, night, sliding-door, gate, thumb latches.

The upper examples in Fig. 2826 are a *thumb*-latch and *gate*-latch respectively. The lower is a *gravitating* gate-latch, the catch and its keeper being shown detached.

A reversible latch is one in which the bevel of the bolt can be set in either direction, so as to make the latch answer for a right or a left hand door. The bolt is simply pulled out, turned half round, and then released, the spring bringing it back to place.

Fig. 2827.



Reversible Latch.

2. (*Knitting-machine.*) The piece hinged to the needle, which closes over the engaged loop to hold it in position in the needle while the latter is penetrating another loop. The latch is subsequently opened by the latch-lifter to allow the loop to be pushed back upon the needle, and is then closed by the latch-closer to enable the *knock-off* to disengage the formed loop or stitch. The *latch* is sometimes called the *fly*.

3. (*Nautical.*) *a.* A cord clamp which holds the in-board end of a mackerel-line. A *mackerel-latch.*

b. A loop on the head-rope of a bonnet-sail. A *lasket.*

Latch-clos'er. (*Knitting-machine.*) The piece which closes the latches, to enable the *knock-off* to slip the formed loops off the needles.

Latch-key. A private key for a street-door latch.

Latch'ing; Las'ket; Latch. (*Nautical.*) A loop formed on the head rope of a *bonnet-sail*, by which it is connected to the foot of the sail to which it forms an appendage.

Latch-lift'er. (*Knitting-machine.*) The rod or finger which lifts and reverses the latches to enable the loops or stitches to be pushed back along the needles.

La-teen'-sail. (*Nautical.*) A triangular sail, having its upper edge fastened to a long yard which is inclined at an angle of about 45°. The yard is slung at a point three quarters of its length from the peak end. It is used principally in the Mediterranean, upon *xebecs*, *galleys*, and *feluccas*, which have three, two, and one mast, respectively.

Lateen-sails of papyrus were used by the ancient Egyptians on the Nile.

La-teen'-yard. (*Nautical.*) One used in extending a *lateen*-sail. It is slung at a point one quarter of the length from the tack of the yard.

Lat'er. A brick or tile.

Lath. 1. (*Carpentry.*) One of the strips of wood nailed to the rafters to support the roof-covering.

2. (*Plastering.*) One of the narrow strips nailed to the studs of partitions to support plastering.

Strips of metal are sometimes used for this purpose in fire-proof structures. Such lath have means for securing to the studding or wall, and also affording a *key* to the mortar which is laid thereon.

Slips of wood, used in plastering, are noticed by Pliny.

Lath floated and set fair. Three-coated plasterers' work. The first is called "*pricking-up*"; the second, "*floated*"; the third, "*finishing.*"

Lath laid and set. Two-coated plasterers' work.

The first is called *laying;* the second, *finishing.*

Metallic lath for wooden or iron partitions has been made in various forms, of which the annexed instances may be given : —

a has a corrugated plate and transverse rods, behind which latter the plaster makes its lock.

b has plates with dovetail holes in which the plaster fastens.

c has corrugated plates which catch upon hooks on the studding.

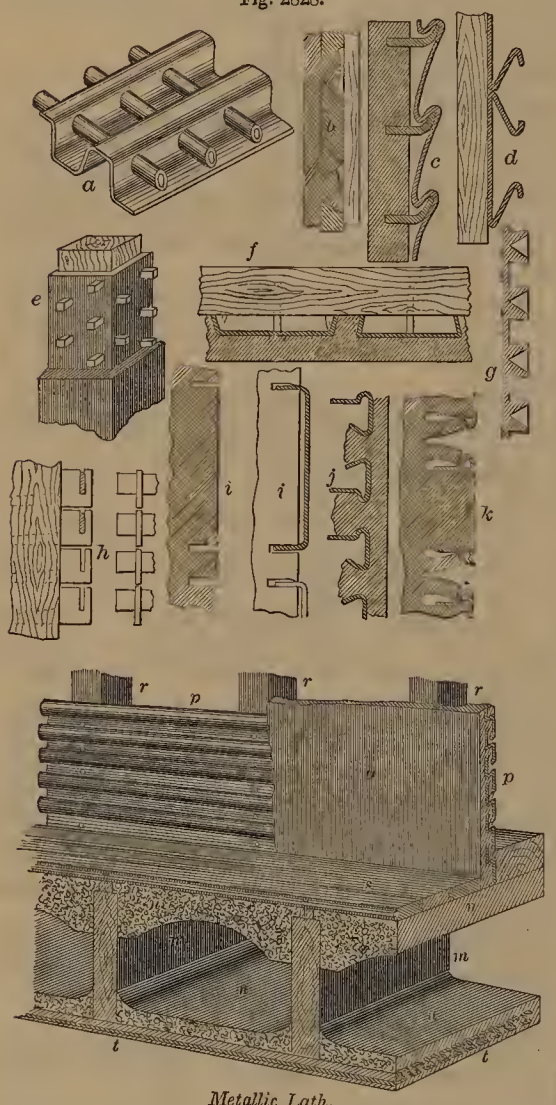
d has plates which present bent prongs.

e has metallic plates with frustums presenting their bases outwardly.

f has strips with flanged corrugated edges.

g has sheets with projecting studs of frustal form.

Fig. 2828.



Metallic Lath.

h has iron slats which are held by slotted iron plates driven into the studding.

i i show a form in which the edges of bent slips enter slots in the studding.

j has bent strips which occupy depressions in the studding.

k has means for pinching the edges of the lath.

The lower figure represents a portion of a structure in which the wooden joists and studding are so isolated from each other and protected externally that the wood cannot be readily fired by exposure to flame.

m m are the wooden joists ; *n n* protecting bodies of concrete ; *t* the corrugated lath whose trough-like shape enables it to form a key for the plaster, to protect the joist from the effects of fire in the room below, the portion of the plaster in the trough acting as a clinch for the outer portion of the plaster which forms the ceiling surface.

The same may be said in regard to the wall plastering *o*, which is spread upon similar metallic lathing *p* on the studding *r*. The upper body of concrete *n* extends above the joists, so as to isolate the flooring *s* therefrom.

This plan is a compromise, and retains the usual wooden portions of a floor or partition, excepting the wooden lath, for which corrugated sheet-iron laths are substituted. The laths are perforated for attachment by nails in the usual manner.

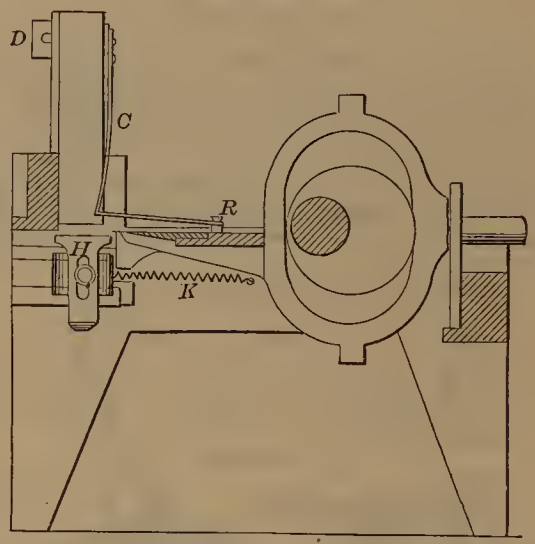
3. A bedstead slat for supporting the mattress. See BED-BOTTOM.

Lath-brick. A long brick, 22 × 6 inches, used for oast or grain-kiln floors.

Lath-cut'ter. One for cutting lath from a board or balk.

The example is one of the former, in which the lath is cut by a reciprocating knife from a board

Fig. 2829.



Lath-Cutter.

which is fed thereto by its gravity. A flexible adjustable guide *C* preserves the perpendicularity of the board and releases it after the cut. The rests *H* reciprocate in dovetail slides and are operated by the bumper on the knife-frame *R* and the recoil spring *K*. The knife is reciprocated by a cam and yoke.

Lathe. 1. A machine in which the object revolves while it is shaped by a cutting-tool applied to it.

Turning, as an art, is believed to have originated with the potter's-wheel, which consisted of a simple disk or table rotating in a horizontal plane, upon a vertical shaft. This wheel was used only with plastic material formed by the hand, and is as ancient as the oldest Egyptian monuments, in which the god Ptah is represented in the act of molding man upon the throwing wheel.

The turning-lathe proper (*tornos*), having its work suspended on horizontal centers, appears to have been unknown in Egypt, but was mentioned by the Greek writers some centuries before our era, and was employed on wood. Its use for metal is of comparatively recent origin.

The credit of the invention is given by Diodorus Siculus to Talus, the grandson of Dædalus, about 1240 B. C., and by Pliny to Theodorus of Samos. The initial mode is probably the *pole-lathe*, in which the stick of wood is suspended on two centers and rotated by power applied directly to it, while a cutting-tool is supported on a rest and brought into contact with the rotating wood. An advanced form would be to apply the power to a mandrel whose end formed one of the centers and upon which the wood was chucked.

Fig. 2830 shows the foot-lathe of the Kabyles, an African people. The turner is shown making a wooden bowl. The motion is reciprocating; as the man presses with his foot in the bight of the cord the bowl is rotated towards him, and he applies the chisel or other cutting-tool. He then lifts his foot, and the elasticity of the spring-bar, which has been bent over, rotates the bowl in the other direction and

Fig. 2830.

Pole-Lathe (Africa).

lifts the bight of the rope, ready for another effective stroke.

The lathe of the native East-Indian consists of two upright pieces of wood driven into the ground at the requisite distance for holding the work, with spikes projecting horizontally. The work is held between these spikes and made to rotate backward and forward by a bow held in the left hand, and the string of which is passed once round the wood. Fig. 2831 shows a pole and treadle lathe used by people of the Carpathian Mountains. The work *a* is suspended on centers *b b*, and rotated by the cord which connects the end of the spring-pole with the treadle *c*. The chisel rests upon the bar.

Fig. 2831.

Lathe of the Carpathians.

The earliest screw-lathe known is one described in the work of Jaques Besson (see Plate 9 of that work) published at Lyons, France, in the year 1578. This curious lathe, which is also illustrated and described on page 616, Vol. II., Holtzapffel's "Turning and Mechanical Manipulation," has its tool traversed alongside the work by means of a guide-screw, which is moved simultaneously with the work to be operated upon, by an arrangement of pulleys and cords clearly shown in the engraving. Besson's machine was capable of cutting screws of any pitch by the use of pulleys of different diameters, and could be made to cut right-hand or left-hand screws at pleasure, by crossing or uncrossing the cord. The inventor also describes its application to elliptical, conical, or other solids.

A metal-turning lathe, in its most essential details, is found described on page 214 of "Mechanick Exercises, or the Doctrine of Handy Works," by Joseph Moxon, hydrographer to King Charles II., printed in London, 1694. This is cited, however, rather as one of the earliest intelligible and illustrated descriptions which have come down to us, than as fixing the actual date, — for evidence exists of its much earlier origin; for example, a bronze drinking-vessel, five inches in diameter, and *evidently turned*, was exhumed from an ancient tomb in Thebes, Egypt. This vessel may be seen in the Abbott collection, museum of the Historical Society at the corner of Second Avenue and Eighth Street, New York.

In the earlier construction of the lathe, the *slide-rest* was the first great step toward the principle of the *slide-lathe*, and no doubt led to that invention, which was considered impracticable before planing-machines were made of sufficient magnitude to plane a lathe-bed of even small dimension. A few slide-lathes had indeed been made, the beds of which were composed of a timber framing, covered with iron plates on the upper side to preserve the surface, similar to those which were previously used for the ordinary hand-lathes, with the exception that the outer edges of the iron plates were made of suitable shape to form the Vs for the carriage to slide upon. It was not, however, until some time after the introduction of the planing-machine that slide-lathes came into general use, and their utility was fully acknowledged.

The application of a *screw* to the *slide-lathe*, so as to render it capable of both *sliding* and *screw-cutting*, was the next important improvement; and a great amount of time, perseverance, and capital was expended by a few persons in endeavoring to perfect this portion of the lathe. A short screw was first made, as accurately as possible with the rude means then possessed, from which one was cut double the length, by changing the turned bar end for end in the lathe after cutting one half. Subsequently, by following out this principle, screws were made of any length required.

After this, the *surfacing motion* was introduced, and also the use of a shaft at the back of the lathe, in addition to the regular screw, for driving the slid-

ing motion by rack and pinion, instead of both the motions of sliding and screw-cutting being worked by the screw alone; for it was found that the threads of that portion of the screw nearest the fast head-stock, being most in use, were worn thinner than the other parts; and, in consequence, the lathe did not cut a long screw with the degree of accuracy which it otherwise would have done.

Thus, step by step, improvements were gradually brought forward; the fore-jaw and universal chucks and other important appliances were added, so as to render the lathe applicable to a great variety of work, even cutting spiral grooves in shafts, scrolls in a face-plate, skew-wheels, and also turning articles of oval, spherical, or other forms. The duplex lathe, with one tool acting in front and the other behind the work, is also found to be a very useful arrangement for turning long shafts, cast-iron rollers, cylinders, and a great variety of work, where a quantity of the same kind and dimensions has to be turned. See DUPLEX-LATHE.

The *slide-rest* is the invention of General Sir Samuel Bentham, and is the precursor and original of the planing-machine for metal. General Bentham is the inventor of the planing-machine for wood, patented in England in 1791. It seems to have been a reciprocating machine, acting after the manner of a hand-planer. He afterward invented the planing-machine with circular cutters. See PLANING-MACHINE.

Since the beginning of the century, numerous improvements in the lathe, some of them valuable, have been made the subjects of letters-patent in this country and in England; so numerous, indeed, are they that a bare recitation of their titles would fill considerable space. The more important improvements will be found described in the book called "The Lathe and its Uses; or, Instruction in the Art of turning Wood and Metal," copiously illustrated, published by Wiley & Co., New York; and in "Turning and Mechanical Manipulation," by Joseph Holtzapffel, an English work not republished in the United States.

Lathes are known by various names, according to construction, mode of driving, etc.

The *bar-lathe* has a single beam or shear, generally of a triangular shape. On this the heads or puppets slip.

The *bed-lathe* is the usual form, and has two parallel shears.

The *center-lathe* has head and tail stocks, which afford centers for each end of the work turned.

The *chuck-lathe* supports the work being turned, by means of a grasping tool or socket on the mandrel of the head-stock.

The *foot-lathe* is driven by a treadle.

The *geometric lathe* is an instrument for producing wavy or eccentric patterns with a general concentric arrangement. See GEOMETRIC LATHE.

The *hand-lathe* is driven by a crank or bow, and is of small size, for the bench or table.

The watchmaker's lathe is a small bench-lathe, sometimes having pivot centers, on which the work is turned by a bow, and sometimes a *hand-lathe* or a foot-lathe of small proportions.

The *last*-lathe is a LATHE FOR TURNING IRREGULAR FORMS (which see).

The *mandrel-lathe* supports the work on a spindle, which is attached to the axle of the head-stock, or on the head and tail centers, according to circumstances.

The *pivot*-lathe is a small bench-lathe whose centers are the ends of rods clamped in the heads and not partaking of the revolution.

The *pole-lathe* supports the work on puppets, and the cord passes from the treadle two or three times round the work, and then upward to a spring-bar. See Figs. 2830, 2831.

The *power-lathe* is driven by horse-power, water, or steam.

The *rose-engine* lathe is a form of the geometric.

The *spindle-lathe* has a rotating axis in the head-stock, to which the work is attached.

The *spoke-lathe* is a LATHE FOR TURNING IRREGULAR FORMS (which see).

The *turn-bench* is a small portable lathe for the work-bench or desk.

The parts of a lathe are, —

The *bed*, *sheers*, *cheeks*, *sides*, on which the puppets slide. The *puppets*, which form the *head-stock* and *tail-stock*. The *mandrel*, or live spindle of the live head, and on which is the speed-pulley. The centers on the *live* or *front spindle*, and the *dead* or *back spindle*, respectively, on which the work is turned.

The *fly-wheel* (of a foot-lathe), on which is the cord passing to the *speed-pulley* of the head-stock.

The *treadle*, or *foot-board*, to which the power is applied.

The *collar-plate*, *cone-plate*, *face-plate*, *chuck*, or other means of connecting the work.

The *rest* for the tool.

See under the following list of lathes and appliances: —

Axle-lathe.
Back-poppet.
Ball-turning lathe.
Bar-lathe.
Beaded-work lathe.
Bead-tool.
Bearer.
Bed.
Bed-lathe.
Belt-shifter.
Belt-tightener.
Bench-lathe.
Bevel-tool.
Blanchard lathe.
Boring-collar.
Bottom-tool.
Branch-chuck.
Broad.
Button-lathe.
Carrier.
Car-wheel lathe.
Center-chuck.
Centering-tool.
Centers.
Chaser.
Chasing-lathe.
Chuck.
Chuck for wood lathes.
Collar-plate.
Comb.
Compound-rest.
Cone-plate.
Cranked tool.
Crank-hook.
Cutter-head.
Cycloidal engine.
Dead-head.
Dog.
Dog and driver chuck.
Dog for wood-lathes.
Dog-lathe.
Driver.
Duplex-lathe.
Eccentric chuck.
Elliptic chuck.
Engine-lathe.
Face-plate.
Flat-tool.
Fluting-lathe.
Foot-lathe.
Foot-wheel lathe.
Fork-chuck.
Founder's lathe.
Gage-lathe.
Geometric chuck.
Geometric lathe.
Hand-lathe.
Hand-wheel lathe.
Hanging-tool.
Heading-tool.
Head-stock.
Heel-tool.
Hollow-mandrel lathe.
Hook-tool.
Inside-tool.
Ironing-lathe.
Last-lathe.
Lathe-chuck.
Lathe-dog.
Lathe for irregular forms.
Leading-screw.
Mandrel-lathe.
Nulled-work lathe.
Oval chuck.
Oval lathe.
Overhead motion.
Pail-lathe.
Parting-tool.
Pivot-lathe.
Planisher.
Point-tool.
Pole-lather.
Poppet-head.
Potter's lathe.
Power-lathe.
Puppet.
Quarter-hollow tool.
Quarter-round tool.
Rest.
Rigger.
Ring-chuck.
Rose-engine lathe.
Round tool.
Screw-cutting chuck.
Screw-cutting lathe.
Screw-tool.
Scroll-chuck.
Seal-engraver's lathe.
Shafting.
Shafting-lathe.
Shears.
Side-tool.
Skew-chisel.
Slide-lathe.
Slide-rest.
Spherical lathe.
Spindle-lathe.
Spoke-lathe.
Straight-line chuck.
Surface-chuck.
Tail-piece.
Throw-lathe.
Tool-holder.
Tool-post.
Tool-rest.
Transferring-lathe.

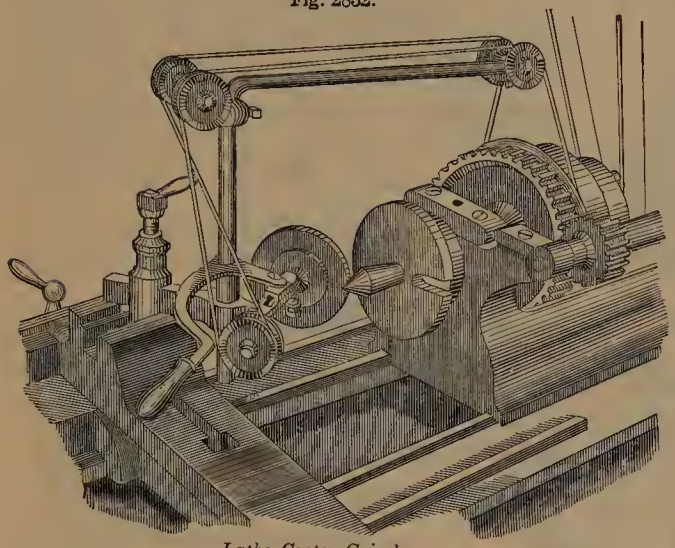
Treadle.
Turn-bench.
Turning-lathe.
Universal chuck.
Watchmaker's lathe.
Wheel-lathe.
Whirling-table.
Whisket.
Wood-turning lathe.
Wrist-pin turner.

2. (*Weaving.*) The wooden frame beam which forces up the weft. The *lay* or *batten*.

It may consist of these parts : —

The *swords ;* two upright laths at the ends of the race.

Fig. 2832.



Lathe-Center Grinder.

The *lay-cap* or *pull-to ;* the top bar by which it is handled.

The *reed*, *sley*, or *slay*, which has parallel slips of metal or cane which separate the warp-threads and batter against the weft.

The *race*, or shuttle-track.

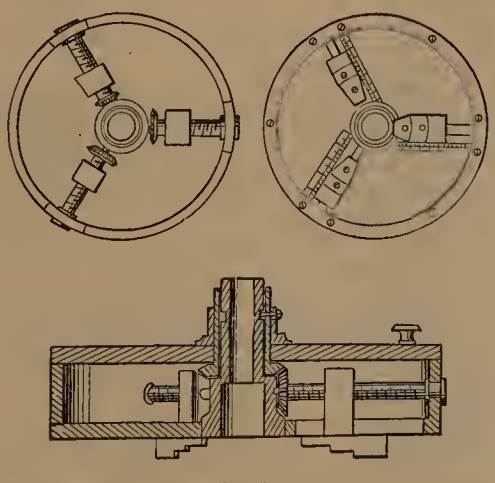
The *shuttle-boxes*, at the ends of the race.

The *picker*, *pecker*, or *driver*, which strikes the *fly-shuttle* and drives it along the *race* through the *shed*, which is formed by the decussation of the warp.

The *picker-cord*, which jerks the *picker*.

Lath-cen'ter Grind'er. An attachment to a lathe for truing the hardened live center *in situ*, by means of an emery-wheel rotated by a band conducted over idlers from the lathe-pulley.

Fig. 2833.

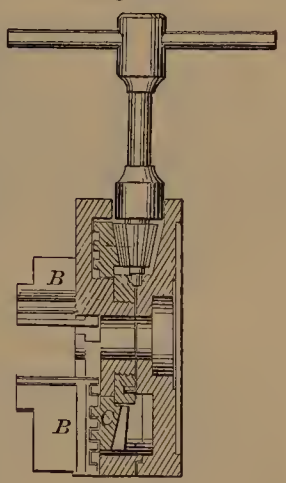


Lathe-Chuck.

Lathe-chuck. One for holding work to the live mandrel, or a mandrel between centers of a lathe.

Fig. 2833 shows a universal chuck, in which the gear is placed at the center of the chuck, and pinions are arranged at or near the inner end of the driving-screws. The gear-hub is retained in place by a set-screw made to play in a groove in the gear-hub. Scales on the face-plate serve as guides in setting an eccentric, and also in adjusting the jaws at the right point.

Fig. 2834.



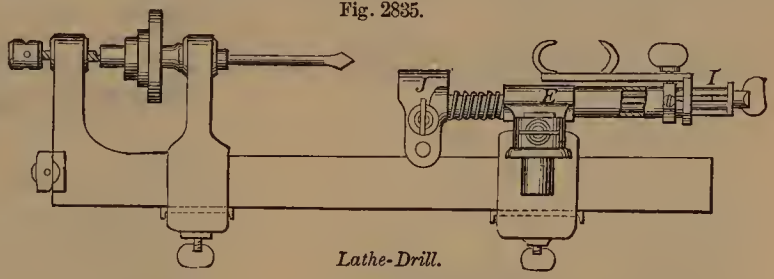
Lathe-Chuck.

The right-hand view is on an enlarged scale, and shows the dogs, the screws, and the back-plate, carrying the bevel-gear which mashes with the pinions on the dog-screws.

In Fig. 2834, the dogs *B B* are advanced or receded by the action of a wheel *C* with a spiral worm on its face and a bevel-gear on its back, actuated by the bevel-pinion which is turned by the key. See also CHUCK.

Lathe-dog. A piece on a mandrel or on work in a lathe, which, by contact with a pin on the face-plate of the live head, is caused to turn the work. See DOG.

Fig. 2835.



Lathe-Drill.

Lathe-drill. A bar-lathe arranged as a horizontal drilling-machine. The work is grasped by the vise *J*, and fed to the tool by the slipping of the piece *I* in the tube *E*.

Lathe for turn'ing Ir-reg'u-lar Forms. Previous to the present century, we read in the works of Condamine, De la Hire, and Plumier of lathes adapted to turn irregular forms.

De la Hire shows how all sorts of polygons may be made by the lathe, and Condamine shows how a lathe may be made to turn all sorts of irregular figures by means of tracers moved over the surface of models and sculptures, medals, etc.

Plumier's work enters extensively into the art of turning. Among other machines, he describes the slide-rest in combination with a planing-machine. This he calls an English invention.

In addition to the citation of these authors, we may refer to a number of elaborate machines made by Sir Samuel Bentham, 1793, and Joseph Bramah, 1802.

The machine invented by Brunel for making the groove around ship's blocks for the insertion of the ropes by which they are attached to the rigging has a revolving disk of brass with two cutters. It trav-

erses around one side of the block, receiving its direction from a shaper placed parallel thereto, making the groove deeper at the ends than at the central part, where the sheave-pin is inserted.

The parent of all recent machines of this kind is, however, the lathe invented by Thomas Blanchard of Philadelphia, and patented by him September 6, 1819.

This lathe for turning irregular forms contains the generic idea of all machines for duplicating shapes by using a model in conjunction with a blank, the outline of the model guiding the cutting-tool to produce a duplicate from the blank.

This ingenious device may be said to have wrought a complete revolution in that branch of wood-working to which it appertains. Originally applied to turning lasts, it has since been employed to shape the most difficult forms, gun-stocks for example, which it was formerly imagined could only be produced, and in a far less finished manner, by the drawing-knife, the gouge, and the chisel.

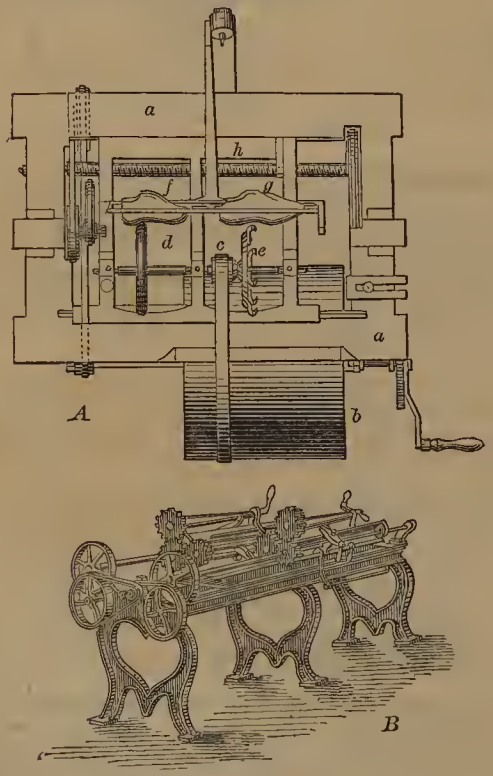
Fig. 2836, *A* shows a plan of the machine as originally patented. *a* is the frame, *b* a drum driving the pulley *c*, whose shaft serves as a common axis to the rapidly rotating pattern-wheel *d* and cutter *e*. These are maintained respectively in contact with the pattern *f* and the roughed-out block *g*, which is to be turned, so that as the former moves transversely back and forth the latter follows its motions.

The common axis of the wheel and cutter is caused to recede or advance, as projections or depressions of the model are brought in contact with the pattern-wheel, by means of a spring. A screw *h* produces a longitudinal movement.

It is obvious, as stated by the inventor in his specification, that various alterations in the positions of the working parts, with relation to each other, may be made without interfering with the general principle.

B, Fig. 2836, is a recent form of lathe of this description, all the parts of which are of iron.

Fig. 2836.



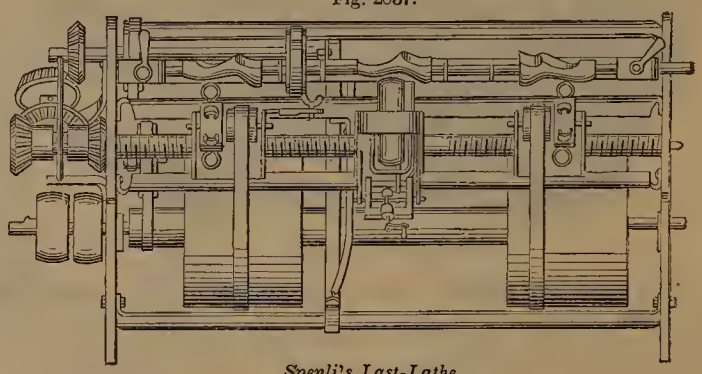
Lathe for turning Irregular Forms.

In Spenli's lathe, a right and left last are turned at the same time in the same lathe, and from a single pattern, which may be larger or smaller than the last produced. The cutter-heads are traversed by the right and left hand screws of the single spindle, so as to simultaneously advance or recede from the central wheel, which is actuated by the pattern-last. By shifting the bolt in the slotted lever, the motion of the pattern-wheel head can be accelerated or retarded to make the lasts respectively smaller or larger than the pattern, while preserving the relative proportion of the parts of each last.

There are several forms of the machine :—

1. The slowly revolving model and work ; a rapidly rotating cutter acting on the work, and regulated as to proximity to the axis of the work by a tracer which rests against the rotating model.

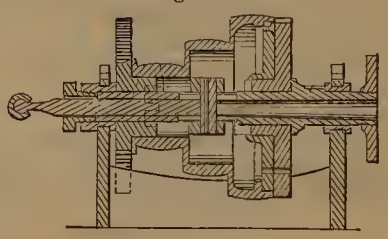
Fig. 2837.



Spenli's Last-Lathe.

2. Rapidly rotating work and a rapidly rotating cutter, whose proximity to the work is regulated by a templet.

Fig. 2838.



Lathe-Head.

3. Rapidly rotating work and a cutter actuated by a templet.

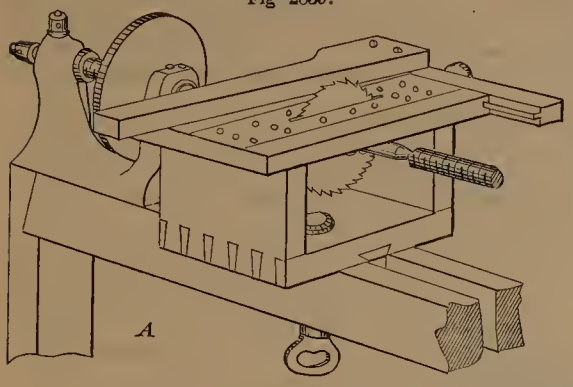
Lathe-head. The poppet-head which contains the mandrel, on which is a cone-pulley for the belt and a means for attaching a face-plate or chuck for the work.

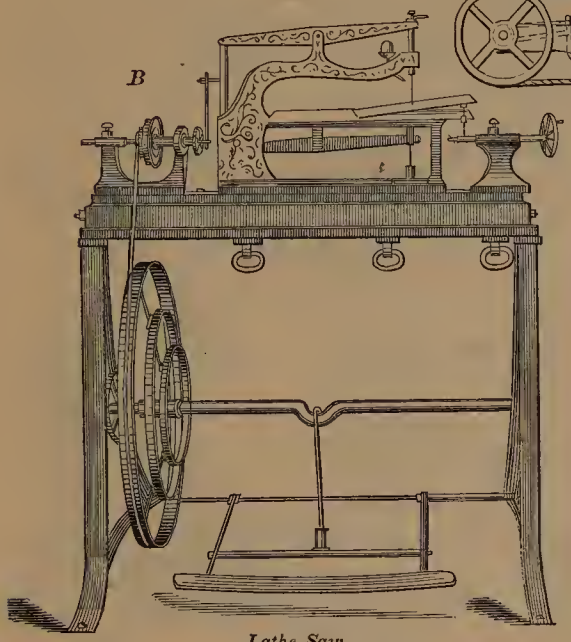
Lathe-saw. For some of the smaller uses of circular saws they may be retained on the mandrel, supported on the lathe centers, as shown at *A*, Fig. 2839, while a bench is arranged upon the shears of the lathe. The wooden box is secured by a screw-clamp beneath the shears, and the platform is hinged to the back of the box, the saw projecting through a slot in the platform.

A *fence* can be arranged on the platform to act as a gage and guide in slitting a number of pieces to a size. A guide against which the work may be held, so as to present it at any angle to the saw, is a convenient adjunct.

B (Fig. 2839) shows a small fret-saw mounted on an ordinary lathe. The table is adjustable in hight, so that, being half an inch above the lathe-center, the saw will have an inch stroke, or a quarter of an

Fig 2839.



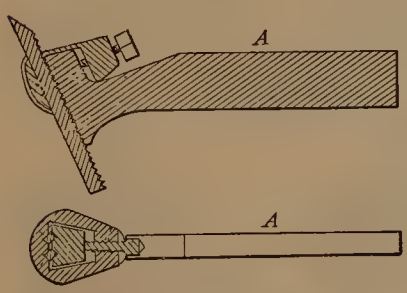


Lathe-Saw.

inch will give a half-inch stroke, and so on. The post uniting the back ends of the levers is connected to a wrist on the face-plate of the lathe-mandrel.

Lathe-tool Hold'er. A socket or holder for a lathe-tool, having a shank *A* which is held by the set-screw on the post of the slide-rest.

Fig. 2840.

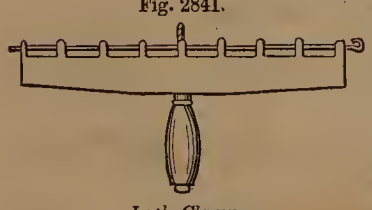


Lathe-Tool Holder.

Lath'ing-clamp. A clamp to hold a set of spaced laths while nailing to the studding.

Lath'ing-hammer. A hatchet, whose *bit* and *poll* present a straight line, so that the bit does not interfere with nailing up laths in corners of rooms.

Fig. 2841.



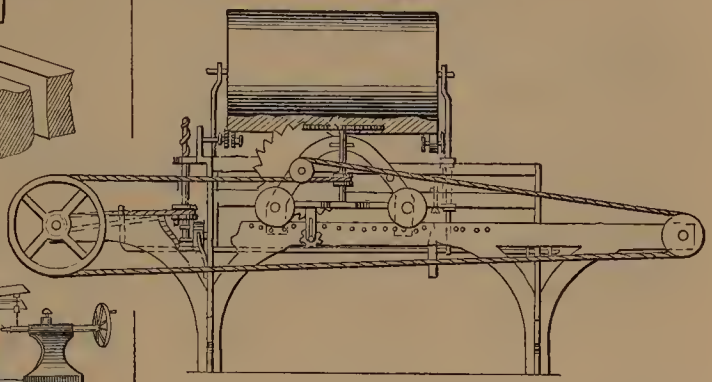
Lath-Clamp.

The bit is used for cutting lath to a length, and it has a notch for withdrawing nails.

Lath-nail. A small cut nail (about 4 *d.*), for fastening laths to studding.

Lath-saw'ing Ma-chine'. One for sawing lath from the board or the bolt. The cylindrical log is mounted on journals upon gravitating guide-bars, and supported and rotated by rollers. The laths are sawn from its periphery by saws cutting rectangularly to each other.

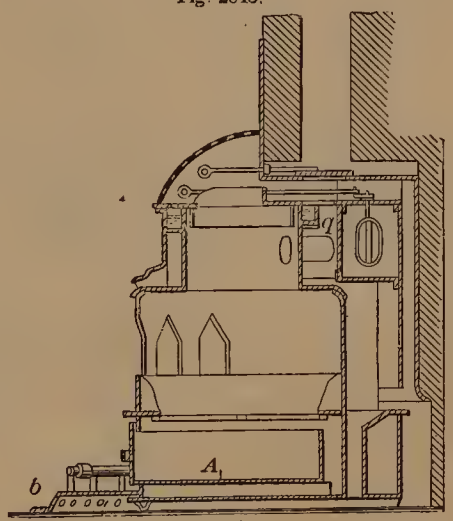
Fig. 2842.



Lath-sawing-Machine.

La-trobe'. A form of stove which sets into the fireplace of a room, has a projecting ornamental front, and is arranged for heating floors above. In the example, the furnace portion has a means of direct access to the flue in kindling fire or urging a strong draft, the lower damper shown in the cut, which moves the butterfly-valve in the partition between

Fig. 2843.



Latrobe.

the downcast flue and the upward or reverting flue, which conducts the smoke to the chimney. The upper damper governs the opening by which the air heated by the stove is conducted to the hot-air flue and led upward to the registers of the rooms on the upper floors. The lower plate *A* is elevated above the floor, and the air heated beneath it is also conducted to the room at the passages leading to the upper rooms. The air is admitted through a perforated extension-plate *b* of the base-plate. *q* is a vessel for water, which is evaporated and mingles with the hot air which passes to the room or rooms.

Lat'ten. Thin metal. Metal in sheets.

In the Middle Ages, a thin plate of brass or bronze, used for cutting into crosses, bending into candlesticks, etc.

Black-latten is brass in milled sheets, used by braziers and for drawing into wire.

Shaven latten is a thinner article.

Roll-latten is polished on both sides, ready for use.

Latten-wire is wire made from latten-plate. It was thus made before the invention of wire-*drawing*.

Lat'ten-wire. Wire made from strips of latten.

Lat'ter-kin. (*Plumbing.*) A pointed piece of hard wood, used for clearing out the grooves of the *cames* in *fret-work* glazing.

Lat'tice. A structure of crossing laths or bars, as a *lattice-window*, *lattice-girder*, etc.

Lat'tice-bridge. A bridge supported by a girder whose web consists of diagonal crossing-pieces. See IRON BRIDGE.

Lat'tice-gird'er. A girder consisting of two horizontal bars united by diagonal crossing-bars. See IRON BRIDGE.

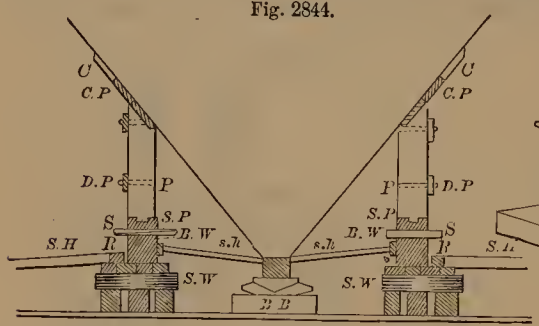
Lat'tice-truss. One having horizontal chords and inclined intersecting braces.

Lat'tice-win'dow. A window formed of leaden frames, called *cames*. The panes are usually diamond-shaped, and are set with an acute point upward.

Launch. 1. (*Shipbuilding.*) A term comprehending the apparatus for launching a ship.

S W, the *slip-ways* or *sliding-ways*. The structure above them, giving temporary support to the ship, is the *cradle*. The *slip-ways* are parallel, inclined platforms of timber, firmly founded on the floor of the slip, and kept steady in their positions

Fig. 2844.



Launch.

by shores *S H*. Their slope varies from 1 in 12 for small vessels to 1 in 24 for the largest. The breadth is from three to four feet. The distance apart of the *slip-ways*, from center to center is about one third of the width of the vessel.

R R are ribbands to act as guides.

B W are the sill-pieces of the cradle-frame, and are termed *bilge-ways*. Their length for wooden ships is about five eighths of the length of the ship.

P, the *poppets*, are posts rising from the sole-pieces *S P*, which rest on the *bilge-ways*.

S, the *slices*, are wedges by which the *cradle* and ship are lifted clear of the *building-blocks B B*, to prepare for launching.

The upper ends of the poppets *P* rest against planks *C P*, which are prevented from slipping by means of the *cleats C*, bolted to the side of the vessel.

D P, the *dagger-planks*, are longitudinal ties by which the *poppets* are stayed.

S H, *s h*, are outer and inner shores, by which the *bilge-ways* are held to their places on the *sliding-ways*.

2. (*Nautical.*) The largest boat belonging to a ship of war. It is only used for service which cannot be performed by the smaller boats, being hoisted in board and kept on deck just abaft the foremast, where it serves as a receptacle for lumber and stores. In large men-of-war the launch is sometimes decked over, and is capable of mounting several light guns. The corresponding boat of merchant vessels is called the *long-boat*.

The launch is from 30 to 40 feet long, having a beam from .29 to .25 of its length. It has 10 or 12 oars, and is carvel-built.

Steam-launches are now used in the navy, and as despatch and revenue boats.

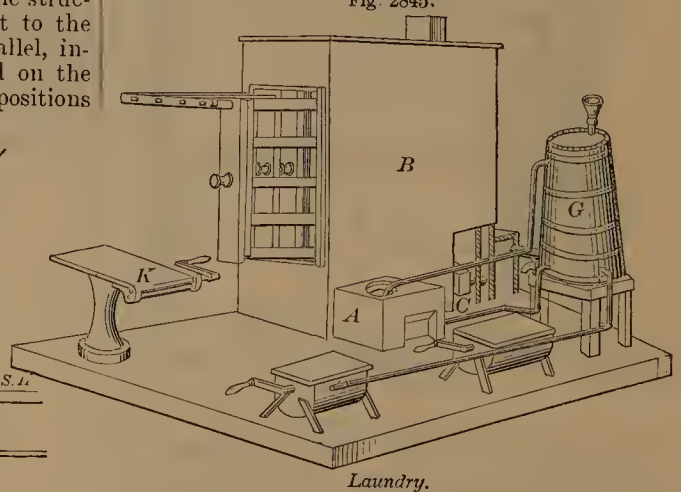
Launch-en'gine. Launch-engines generally consist of a boiler with engines attached thereto, and are used for propelling the launches of large ocean steamers in shallow harbors, etc. Such launches are used for general service, the transportation of men and stores, and as despatch-boats.

Laun'der. (*Mining.*) A wood water-gutter or pipe. A trough for conveying water to a stamp-mill or other hydraulic apparatus for comminuting or sorting ore.

Or a trough or box to receive the slimes from the stamps.

Laun'dry. An apartment arranged for washing, drying, starching, mangling, and ironing clothes, as in the example, which has a boiler *A*, drying-

Fig. 2845.

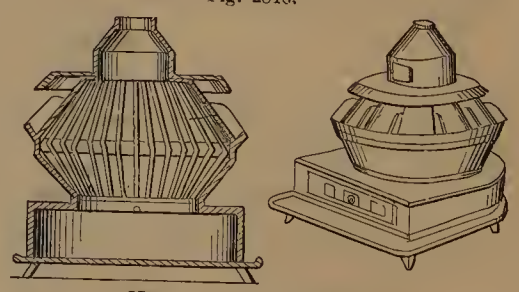


Laundry.

closet *B*, water-reservoir *G*, mangle *K*, and washing-machines.

Laun'dry-heat'er. A stove adapted to the uses of a laundry, especially for heating smoothing-irons, having an inclined heating-surface with a shelf.

Fig. 2846.



Heater for Smoothing-Irons.

Law-bind'ing. (*Bookbinding.*) A plain style of binding in leather of the natural tan-color; calf or sheep.

Lawn. 1. (*Fabric.*) A very fine white goods, cotton or linen, finer than *cambric*; of an open texture, plain or printed.

White lawn is part of the flowing dress of a bish-

op. It has the odor of ecclesiastical preferment, and, according to Pope, of sanctity also, which is not always the same thing.

"A saint in *crape* is twice a saint in *lawn*."

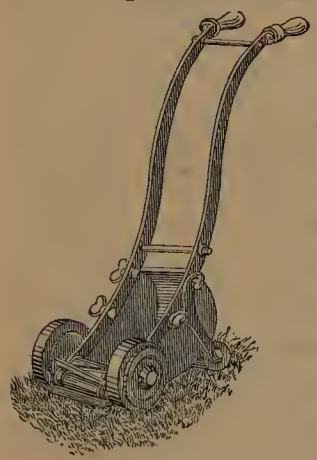
A certain Right Reverend Lieutenant-General was felled a few years since by a round shot. His three-starred coat hid the lawn.

2. (*Porcelain.*) A fine sieve of silk, 300 threads to the inch, through which *slip* for porcelain is strained, to insure an impalpable, creamy fluid. See SLIP.

3. A smooth, grassy surface in the vicinity of a house.

Lawn-mow'er. A machine for cutting sward.

Fig. 2847.

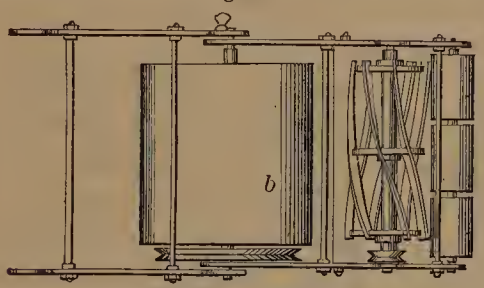


Lawn-Mower.

One form of lawn-mower has a revolving cylinder, armed with spiral knives, which rotate in contact with the rectilinear edge of a stationary knife, placed tangentially thereto. The cylinder is rotated by gear connection to the supporting and driving wheels. The blades of grass are nipped between the edges of the spiral and straight knives, are cut off and delivered into a trough behind the cylinder. The machine is made of different sizes, to cut a swath of from 18 to 36 inches, and is pushed before him by the gardener.

Fig. 2848 has a roller *b* and a set of spiral knives, which cut against a straight edge, near the supporting rollers, which support the hinged portion when

Fig. 2848.

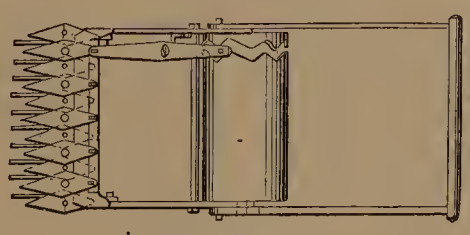


Lawn Roller and Mower.

the mower is brought into action. The mower may be thrown up and over the handle end when the machine is to be used for rolling only.

In Fig. 2849, a row of knives are vibrated by the arm which is oscillated by the zigzag on the roller.

Fig. 2849.



Lawn-Mower.

Lay. 1. (*Rope.*) The direction in which the respective *yarns*, *strands*, etc., are wound in forming them into a *rope*, *hawser*, *cable*, etc.

Hemp is *laid-up right-handed* into *yarns*.

Yarns are *laid-up left-handed* into *strands*.

3-*strands* are *laid-up right-handed* to form a *hawser*.

3-*hawsers* are *laid-up left-handed* to form a *cable*.

The terms signifying the respective forms are, *single-laid*, *hawser-laid*, *cable-laid*.

2. (*Cotton-manufacture.*) *a.* 120 yards of yarn. The yarn is wound on a reel 4½ feet in circumference, 80 revolutions of which make a *lay*, and 7 lays make a *hank* of 840 yards. This is the length of a *hank* of any grade of cotton yarn. The yarn is rated by the number of hanks which go to make up a pound. Nos. 40 to 50 are ordinary *throstle* weaving; Nos. 300 to 400, ordinary mule weaving. By the mule much higher numbers have been reached. No. 700 being exhibited in 1853. See YARN; HANK.

The *lay* is also called a *rap* or *ley*.

3. (*Flax-manufacture.*) 300 yards of linen yarn. See LEA.

4. (*Wool-manufacture.*) A quantity of wool or other fiber in a *willow* or carding-machine.

5. (*Weaving.*) The *batten* or *lathe* of a loom, by which the weft-threads are beaten up in the shed to compact them against their predecessors. See LATHE, 2.

Lay-cap. (*Weaving.*) A slat which lies on top of the *reed*, and which is grasped by the hand in working the *lathe* or *batten*.

Lay'er. 1. (*Tanning.*) A pit containing a strong solution of tannin; used for hides near the conclusion of the tanning process. A *bloomer*.

The pits containing the weaker solution, used in the earlier portions of the process, are termed *handlers*.

2. (*Leather-manufacture.*) A welt or strengthening strip.

3. (*Husbandry.*) A limb laid a part of its length beneath the surface-ground, that it may strike root.

4. *a.* A course of stone or brick.

b. A thickness or bed of puddled clay in a canal.

c. A bed of mortar or cement.

Lay-fig'ure. An artist's model. A jointed figure to clothe in imitation of the human body.

Lay'ing. 1. (*Rope-making.*) The twisting of three (or more) yarns into a *strand*, or of three strands into a *rope*. The rotating hooks by which the *strands* are made are rotated in a direction contrary to the twist of the separate *yarns*. The *rope* again receives a *twist* the opposite of the *strands*. See LAY; ROPE.

2. (*Plastering.*) The first coat of plastering in two-coat work. The surface is made rough by a broom to form a key for the next coat.

The first coat of *three-coat work* is called the *rendering*.

Lay'ing-hook. (*Rope-making.*) One of the iron hooks on the poles of a ropewalk in which the strands are laid as twisted.

Lay'ing-ma-chine'. A machine for laying up yarns into rope. See ROPE-MAKING MACHINE.

Lay'ing-on Tool. (*Bookbinding.*) The tool wherewith the gold-leaf is laid on to the cover or the edge.

Lay'ing-top. (*Rope-making.*) A conical piece of wood placed between the strands, and gradually receded as the lay progresses, in order to keep the twist well to the point at which the strands diverge, and not let it degenerate into a slack twist throughout the length of the strands in the walk.

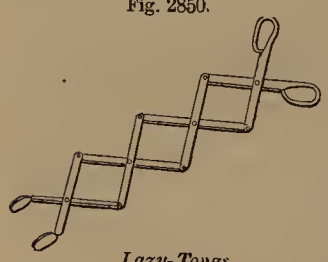
Lay-race. (*Weaving.*) The shuttle-path on the lay of a loom. The *shuttle-race.*

La'zy-back. (*Vehicles.*) A high back-bar to a carriage-seat. It is sometimes made shifting, so as to be removed at will.

La'zy-jack. A lifting-device of compounded levers on the principle of the *lazy-tongs.*

La'zy-tongs. A system of levers, moved by the impulse communicated to the first pair. It is called the lazy-tongs, inasmuch as the grippers are advanced at the same time they are closed together, reaching and grasping simultaneously. The motion is used in many appliances and machines. Gates, guards between platforms of cars, elevators for fire-ladders, drop-lights, and extension gasaliers, and others which will appear occasionally in this work under their respective heads.

Fig. 2850.



Lazy-Tongs.

Lea. 1. (*Flax-manufacture.*) A measure of 300 yards of linen yarn.

Table.

300 yards, 1 *lea.*
10 *leas*, 1 *hank.*
20 *hanks*, 1 *bundle* = 60,000 yards.

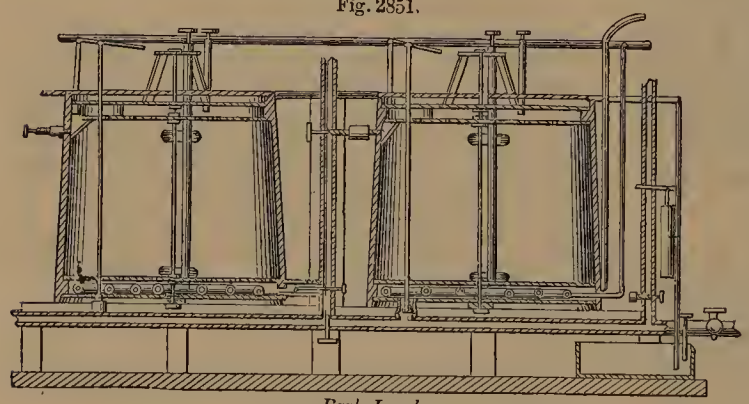
Also called a *lay*, *ley*, *rap*, or *cut.*

2. (*Cotton.*) 120 yards of yarn.

3. (*Weaving.*) *Leas.* One of the alternate sets of threads into which a warp is divided. The whole series is divided into alternate sets, which are to be placed in the loops of the respective *heddles*, so as to be raised and depressed alternately to form the shed in which the shuttle traverses. See WARPING-MILL.

Leach. A vat or chamber in which a body is placed, in order that its soluble portions may be removed by soaking and infiltration. It is a filtering operation in which the liquid removes the soluble matter from the material through which it flows. A familiar instance is the ash-leach.

Fig. 2851.

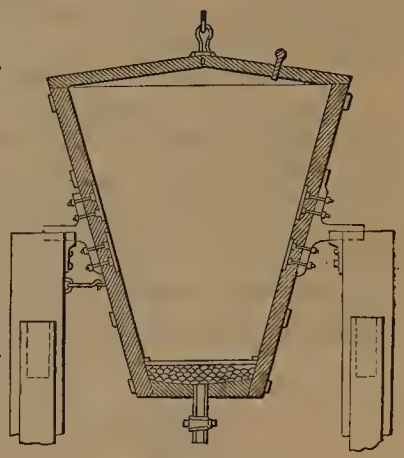


Bark-Leach.

In the bark-leach, the bark is contained between two perforated horizontal partitions in the leach, the lower one having a coiled steam-pipe for heating the contents. The menstruum may be forced through the bark in either direction by means of pipes furnished with valves to determine the said current.

Leach'ing-vat. A vessel in which a material containing a soluble portion is exposed to the action of a solvent, say water, which dissolves and carries away the said portion.

Fig. 2852.



Leaching-Vat.

The example shows the form for leaching-vat used in the process of chlorinating gold. This is made of two-inch plank and painted inside with pitch. Leaden discharge-cocks are placed at the bottom, and pieces of quartz laid loosely under the perforated earthenware false bottom, which is arranged so that it will remain in the vat when the latter is overturned. The vat is closed air-tight by means of a thick lid pressing upon a rubber band on the rim. A pipe inserted into the lid leads the chlorine gas from one vat to another, so that it passes consecutively from one to another in the row until it is exhausted. The vat is charged with auriferous slimes, the lid fastened, gas admitted. After the gold is dissolved, water is admitted, carrying off the chloride of gold to a vat. When the ore is thoroughly leached, it is discharged into a car by overturning the vat, and is then driven off and dumped outside the works.

Lead. 1. A soft, bluish-gray, fusible, ductile, heavy metal. Volatile above red heat. Equivalent, 103.5; symbol, Pb.; specific gravity, 11.44; fusing point, 612° F.

It usually occurs as *galena* (sulphide of lead), and is easily reduced. This is, —

Picked; to remove trash.

Broken and washed; to separate earthy and siliceous matters.

Roasted; a portion is moderately heated to convert it into the sulphate, and then mixed with an unroasted portion. The two are then well roasted to eliminate the sulphur. See LEAD-FURNACE.

The protoxide of lead is litharge, a yellow powder much used in the arts, and as a glaze for pottery and a component in flint-glass.

A compound oxide, red lead, is used as a pigment and a flux.

The white-lead of commerce is a carbonate of lead, and a valuable white paint. See WHITE-LEAD.

The uses of lead are manifold.

Its tractability, softness, fusibility, weight, and cheapness render it particularly suitable for bullets, shot, packing of projectiles, etc.; lining of cisterns, boxes, gutters, and numerous other articles; and it is specially useful in type metal, in all solders and fusible alloys (see ALLOYS), as well as in the composition of various articles of use and ornament, domestic and mechanical.

The lead of commerce is divided into: —

Pig-lead.
Sheet or *milled* lead.
Lead pipe.
Shot.

White-lead. *Chromate of lead.*
Litharge. *Red*-lead.

Lead was known in old times. "They sank as lead in the mighty waters," is a part of the triumphal song of Miriam, 1491 B. C. Job refers to its use for writing-tablets, "An iron pen and lead." A work of Hesiod was preserved for many centuries scratched on leaden tablets. "Iron, tin, and lead" were enumerated by Ezekiel as among the commercial objects of the Tyrian trips to Tarshish. The mines of the Cassiterides, that gave the tin to alloy with copper for the vessels of the temple at Jerusalem, gave also lead to the brave merchants of Phœnicia. The Romans used sheet-lead largely for water-pipes.

2. (*Sounding.*) An ordinary *hand-lead* is a mass of lead, weighing from 7 to 11 pounds, attached to a line of 20 fathoms length. The line is marked at 2, 3, 5, 7, 10, 13, 15, 17, and 20 fathoms; the numbers between the *marks* are called *deeps*. Thus, "by the *mark twain*," "quarter less 5," "and a half 7," "by the *deep* 9," indicate those depths respectively.

The *deep-sea lead* weighs 25 to 30 pounds, with a much larger line marked at every 10 fathoms. See SOUNDING.

3. (*Printing.*) A thin plate of type-metal, less than type-hight, and used to separate lines in printing.

Spaces separate the letters or words.

4. (*Knitting-machine.*) *a.* Solder in which various members are imbedded, and by which they are attached.

b. The tin socket which forms a haft for the knitting-needle.

5. The graphite for filling the grooved cedar staff to form a lead-pencil. See PENCIL.

6. (*Plumbing.*) *a.* A roof covered with sheet-lead.

b. The *came* of the diamond-paned casement.

Lēad. 1. (*Sawing.*) The overhang of a saw, to extend the cut throughout the length of the saw and to carry the saw back in the *kerf* during the return stroke.

2. (*Mining.*) A lode or vein of ore.

3. (*Engineering.*) The distance from an earth-cutting to an embankment.

4. (*Steam-engine.*) *a.* An arrangement of the ports of a steam-valve by which steam is admitted in front of the piston a little before the end of the piston-stroke. Also an arrangement of the ports to provide for the escape of the steam from behind the piston before the completion of the stroke.

When on the *steam* side, it is called *outside* lead. When on the *exhaust*, it is *inside* lead. It tends to check the velocity of the piston at the end of the stroke, and allows of the valve being open and ready to admit a larger supply of steam the instant the motion of the piston is reversed.

b. (*Lead of the crank.*) The setting of the crank of one engine a little in advance of the right angle to the other; namely, at 100° or 110° in place of 90°. This assists in rendering the motion of the piston more uniform, by moderating its velocity at the end of the stroke.

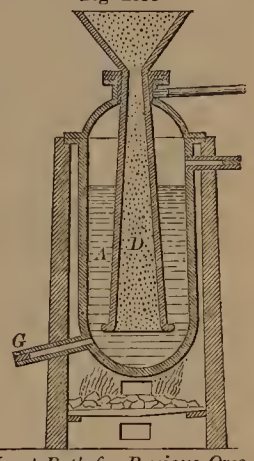
Lead-bath. A process for the extraction of gold or silver from comminuted ore by exposing it mechanically to molten lead, with which it forms an alloy. The subsequent separation is by cupellation or, with silver, by Pattinson's process. See *infra*.

In reducing silver ores, the ancient Peruvians mixed them with galena or lead in portable ovens. It is still practiced in that country. Quicksilver was well known in Peru among the Incas, but was used to make the pigment vermilion, not to amalgamate the precious metals. Hawks writes, A. D. 1572, that the process of amalgamating silver ores with mercury is being substituted for melted lead. See AMALGAMATOR.

In Bursile's English patent, February 12, 1853, the ore is treated with an amalgam formed by the union of quicksilver in a readily fusible alloy of lead and bismuth, or lead, bismuth, and tin.

In Fuller's apparatus, the comminuted ore occupying the central shaft *D* is discharged in a diffused condition beneath the column of lead *A*, which is kept in a molten condition by the furnace beneath. The heavier portion of the alloy is drawn off at times at the pipe *G*. The ore rises through the lead, bringing the particles of gold or silver in contact with the lead, with which they unite. The flow of ore is encouraged by withdrawing air from above the lead by an air-pump. *H* is the discharge-pipe for tailings.

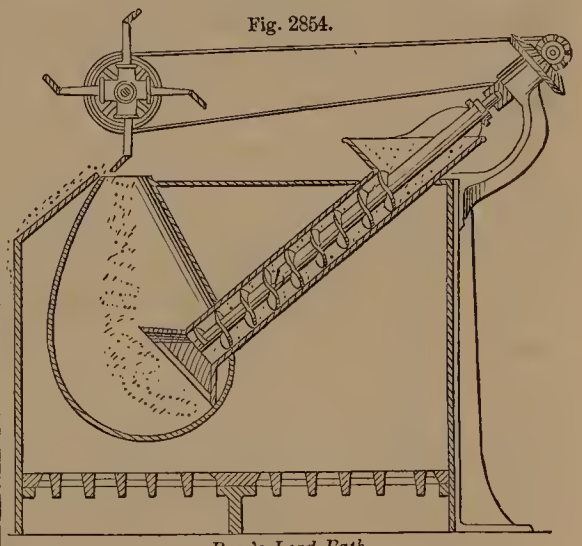
Fig. 2853.



Lead-Bath for Precious Ores.

In Fig. 2854, the vessel is suspended in a furnace through which extends an inclined tube, which discharges its contents near the bottom. The tube has a propelling screw having a shoulder and elastic collar at its bearing, and a grinding plate at its lower end, which works against a grinding surface attached to the lower end of the tube. Above the mouth of the vessel is a wheel which removes the waste ore as it rises to the surface of the molten lead.

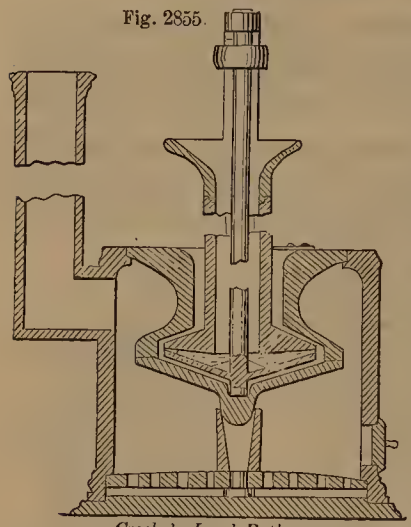
Fig. 2854.



Rose's Lead-Bath.

In Crosby's apparatus the bulbous vessel contains a lead-bath, and is supported in the furnace. The tubular conductor has a disk on its lower end, against which rotates a grinding-plate attached to the vertical axial-shaft. The ore passes down the tube, is associated with lead which flows through openings in the side of the ladle, and the combined mineral and metal are triturated together between the grinding-surfaces, the precious metals becoming amalgamated with the lead while the refuse mineral rises to the top and is skimmed off.

Fig. 2855.



Crosby's Lead-Bath.

Lead-cut'ter. (*Printing.*) A knife for cutting leads which are held in a tray the while.

Lead'er. 1. (*Pyrotechnics.*) A long paper tube of small diameter, enclosing a strand of quickmatch, used for communicating fire rapidly from one point to another. Quickmatch thus enclosed burns much more rapidly than in the open air.

2. (*Nautical.*) A thimble for conducting or guiding a rope which passes therethrough. A *fair-leader.*

3. (*Machinery.*) A *master* wheel or principal wheel in a piece of machinery.

4. (*Printing.*) A row of dots on a line, to lead the eye across the page or column, are called leaders, as : —

Anchor.....page 94.

5. (*Mining.*) A small vein of ore ; indicating proximity of a larger lode, usually leading thereto.

6. (*Surveying.*) The forward one of the two chain-carriers.

7. (*Plumbing.*) A rain-water pipe to conduct to the ground the water collected by the spouting.

Lead'er-hook. A hold-fast hook clasping a *leader* or rain-water pipe, and having its tang driven into the wall of the house.

Lead'ers. Dotted signs for leading the eye across a space. See LEADER.

Lead-flat. A level roof consisting of sheet-lead laid on boarding and joists.

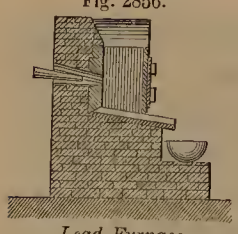
Lead-fur'nace. The furnace by which the ores of lead are reduced to the metallic state. The sulphuret, commonly known as galena, is the principal source from which the pure metal is derived.

The ore having been picked is broken and washed to separate earthy and siliceous matters.

It is then roasted until about half the charge is converted into sulphate of lead, when this and the portion which remains intact are thoroughly mixed together, and the heat rapidly increased, by which means sulphurous-acid gas is driven off and pure metallic lead remains.

The furnace (Fig. 2856) is used in the north of England, and is known as the Scotch furnace. It has a rectangular cavity of masonry, lined with cast-iron. The inclined sole-plate is also of cast-iron, and has an upright ledge at its back and sides, shelving towards the interior, where it passes through the *work-stone* leading towards a pot which receives the molten lead. The tuyere is introduced through the *back-stone*, and the charge is introduced above. The chimney *d* communicates with flues leading to condensing-chambers. Quicklime and powdered charcoal are introduced during the process of reduction, in order to decompose the oxide of lead formed during the operation, and to render the slag less fusible, that it may be the more readily removed. The lead is said to be purer than that obtained by the smelting-furnace, as the heat is lower, and the silver and lead are *sweated out* without reducing the other metals.

Fig. 2856.



Lead-Furnace.

In Carpenter's furnace, steam is used in conjunction with air, the two being introduced either separately or together into the space above the ore.

Lead-glance. Galena. Sulphuret of lead.

Lead-har'ness. That appertaining to the *leading*-horses of a team ; in contradistinction to that for *wheel*-horses, which have breeching to enable them to hold back the vehicle.

Lead'ing-ax'le. An axle ahead of the driving-wheels in British locomotives.

Lead'ing-block. (*Nautical.*) One for guiding the direction of a purchase or rope.

Lead'ing-buoy. (*Nautical.*) A buoy placed as a guide in sailing.

Lead'ing-light. (*Nautical.*) One character of light as displayed for the benefit of seamen on a coast. Two lights are exhibited from two towers ; one may be higher than the other, so as to confer a special characteristic. Certain bearings as to channel are indicated when the lights are seen in one line, the opening of the lights on either side of their conjunction indicating when to tack. Other indications may be given by the conjunction, according to the nature of the case.

Lead'ing-part. (*Nautical.*) The portion of the tackle between the fall and the standing part. It is that portion which passes over the sheaves. The fall is that which, in pulling or easing, does not reach the sheaves.

Lead'ing-rod. One used in draw-boring and polishing the bores of rifle-barrels.

Lead'ing-screw. (*Lathe.*) The longitudinal screw between the *shears* of a lathe, by which the *slide-rest* is moved longitudinally of the lathe-bed. *Lēad-screw.*

Lead'ing-springs. The springs fixed upon the leading axle-box of a locomotive-engine, bearing the weight above. (*English practice.*)

Lead'ing-wheel. A wheel of a locomotive-engine, placed before the driving-wheels.

Lead-lights. A form of casement window in which small panes are fixed in leaden *cames*, which are attached to cross-bars called *saddle-bars.*

Lead-line. (*Nautical.*) A sounding-line.

Lead-mill. A circular disk of lead with an abradant powder, and used by the lapidary for roughing and grinding. See LAPIDARY-MILL.

Lead-nail. 1. A small, round-headed, copper-alloy nail, used for fastening on lead-sheets on roofs.

2. (*Nautical.*) A scupper-nail.

Lead-pot. (*Metallurgy.*) A crucible or pot for melting lead.

Lead from Sil'ver sep'a-rat-ing. Pattinson's method (English) of separating lead from silver is an economical substitute for cupellation. It is founded upon the property which pure lead has of crystalizing out of a solution of silver in lead. The argentiferous lead being fused is allowed to cool slowly, solid crystals of nearly pure lead are first formed, and are separated by an iron strainer from time to time, the melted remainder becoming still richer in silver. At Beaumont's works, Allenheads, Northumberland, the process is conducted in hemispherical, cast-iron pans, each holding about 3 tons of metal and heated by a fire beneath. The process is several times repeated, and the remaining metal is treated by cupellation.

Argentiferous lead ores containing only 3 ounces

of silver to the ton can be profitably worked for the silver by this means, while 20 ounces of silver to the ton scarcely paid when treated by the process of cupellation. See also CUPELLATION; PATTINSON'S POTS; LEAD-BATH.

Lead-pen'cil. A marking and drawing instrument, made by enclosing a slip of graphite (commonly called *plumbago* or *black-lead*) in a casing of wood. This is generally round or hexagonal, but large pencils for the use of carpenters and others are sometimes made oval in section.

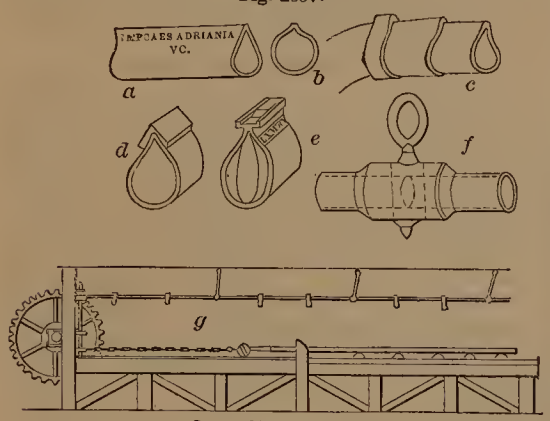
Graphite is generally ranked as a native carburet of iron, but the proportion of the latter metal is so small that it may be considered nearly a pure carbon. It is found in veins, often forming considerable masses. The mines of Cumberland, England, were long the principal source of supply, but are now nearly exhausted. By the old practice, the graphite is first calcined in close vessels at a bright red heat, and is then sawn in slips of the required size, which are inserted in a longitudinal groove in the case, which is formed in two similar parts and grooved by appropriate machinery. The two parts are afterward glued together.

Pencils of the second and inferior qualities are prepared from the dust and other refuse, ground fine and mixed with a kind of fine clay and water, into a paste which is placed in a receiver having an orifice at bottom, of the size and shape of the core. This is cut into proper lengths, straightened, dried at a moderate heat, and afterward baked in close crucibles, when they are ready for insertion into the cases. See GRAPHITE.

America now makes its own pencils. See description of the method pursued at the Dixon Pencil Works, Jersey City, under PENCIL.

Lead-pipe. The use of lead-pipes for conducting water is very ancient. Those of the Romans,

Fig. 2857.



Lead-Pipe Making.

used in their aqueducts, were made out of sheets 10 feet long, and a width proportioned to the diameter required, and averaging about 15 pounds to the square foot. The lead was brought from Britain, and beaten into sheets by heavy hammers. — PLINY.

A sheet 100 inches wide made a pipe weighing 120 pounds to the foot; and would be about 30 inches diameter, allowing for a little lap, were it cylindrical.

The sheets of lead were soldered by the assistance of tin and rosin, the sides being brought flatly together, exposing both edges outside and giving a *pear*-form to the section. Over the joint was soldered a capping ridge, and the whole was hooped around with straps of lead. *a b c d e* show the forms of pipe found at Lyons. Metallic cocks like the modern were used, as seen at *f*.

"Abderahman Ben Alhakem (d. A. D. 852) constructed the Rusafa or embankment along the edge of the river at Cordova, caused water to be brought from the mountains in tubes of lead, and gave orders for the building and erection of numerous fountains in different quarters of the city, with baths of marble." — CONDÉ.

Leaden pipes were used in England as early as A. D. 1236, and Henry III., about 1270, granted the citizens of London the liberty to convey water from the town of Tyburn to the city, by pipes made of lead. A leaden cistern, built round with stone, was erected in 1285. The length of lead-pipe then laid down, from Paddington to the Cross in Cheapside, was 1,096 rods. Cisterns and supply-pipes of lead were numerous in the fifteenth century. The art of casting them was invented by Rev. Robert Brooke, 1539.

In 1582, the water-works of London Bridge were established by Peter Morice, and the water distributed by lead-pipes to certain parts of the city.

In 1613, the New River, an open aqueduct 40 miles long, and having a fall of 3 inches to the mile, was finished by Sir Hugh Middleton, and the water was distributed by wooden mains and leaden branches. In 1804, cast-iron pipes were substituted for the wooden mains.

Lead-pipe is made by *casting*, *drawing*, *pressing*, and *rolling*.

It may be cast in lengths in an ordinary *core-mold*, or consecutive lengths may be cast together by pulling out the core, opening the mold, shifting the pipe along *nearly* its length, replacing mold and core, and then pouring again.

In *drawing* lead-pipe, —

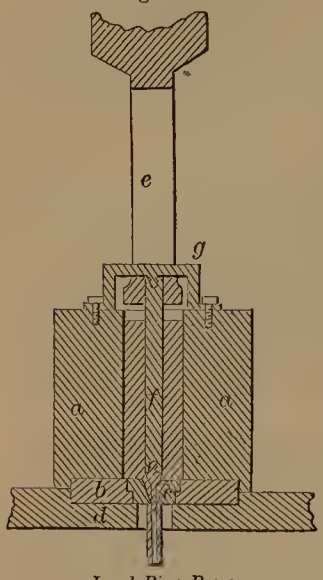
The lead is cast in an iron mold upon a rod of the intended bore, leaving the metal four or five times the thickness it is intended to be eventually. The pipe, with a triblet or mandrel inserted, is then drawn through openings in steel plates of gradually decreasing diameter, which reduce it to the thickness required. When power is applied, the chain winds upon the drum and hauls a little carriage which runs on ways, and has a double claw to engage the head of the mandrel. The perforated steel plate or *whirtle* is held in a cross-bearer above the bench. This mode is shown at *g*, Fig. 2857, and is described in Wilkinson's specification, English patent, 1790.

Instead of the plate, a series of rolls may be employed, gradually diminishing in size, successively reducing the diameter of its exterior, while the mandrel maintains the uniformity of its bore.

The first machine for *pressing* lead-pipe was patented in England by Hague, in 1822. The melted lead was forced through a circular throat whose axis was occupied by a mandrel. The lead was driven through at such a rate that it solidified by exposure to cold surfaces. By another plan, the lead is cast into a short heavy cylinder, and the ingot is forced through a throat at the lower end by the exertion of considerable force upon the piston which fits in the cylinder. This would make a round bar, but occupying an axial position in the middle of the throat is a mandrel, which forms the inside of the tube. This mandrel is supported by a bridge-piece in the cylinder, the lead opening to pass it and closing again before reaching the throat; or the mandrel is supported by the piston, which prevents the cleavage and obviates the necessity for rejunction of the metal. A large number of patents have been granted for machinery for making lead-pipe.

Fig. 2858 illustrates the operation. *c* is the triblet in the holder *b*, which rests on the bed *d*. *f* is a core suspended from the bridge *g*. *e* is the ram,

Fig. 2858.



Lead-Pipe Press.

ing die and mandrel.

which descends upon the cylinder of lead in the box *a*. The bridge traverses a slot in the descending ram.

Lead pipes of great length are formed by pressing the molten metal, contained in a cylinder having a tightly fitting piston connected with the ram of a hydraulic press, which forces the metal between a tube and a solid mandrel; after which it may be coiled on to reels.

Titus's mode of making lead-pipe is by the pressure of a vertical column of melted lead, of sufficient hight to force the metal past a form-

Weight of Lead and Tin Pipe per Foot.

From ⅜ to 5 Inches in Diameter.

Internal Diam.	Thickn's.	Weight.	Internal Diam.	Thickn's.	Weight.	Internal Diam.	Thickn's.	Weight.
Ins.	Ins.	Lbs.	Ins.	Ins.	Lbs.	Ins.	Ins.	Lbs.
⅜	.06	.0424	1	.10	1.5	2	.22	7
⅜	.08	.625	1	.11	2	2	.27	9
⅜	.12	1	1	.14	2.5	2½	3/16	8
⅜	.16	1.25	1	.17	3.25	2½	¼	11
⅜	.19	1.5	1	.21	4	2½	5/16	14
½	.07	.0545	1	.24	4.75	2½	⅜	17
½	.09	.75	1¼	.10	2	3	3/16	9
½	.11	1	1¼	.12	2.5	3	¼	12
½	.13	1.25	1¼	.14	3	3	5/16	16
½	.16	1.75	1¼	.16	3.75	3	⅜	20
½	.19	2	1¼	.19	4.75	3½	3/16	12.5
⅝	.08	.0727	1¼	.25	6	3½	¼	15
⅝	.09	1	1½	.14	3.5	3½	5/16	18.5
⅝	.13	1.5	1½	.17	4.25	3½	⅜	22
⅝	.16	2	1½	.19	5	4	3/16	12
⅝	.20	2.5	1½	.23	6.5	4	¼	16
⅝	.22	2.75	1½	.27	8	4	5/16	21
¾	.08	.0969	1¾	.13	4	4	⅜	25
¾	.10	1.25	1¾	.17	5	4½	3/16	14
¾	.12	1.75	1¾	.21	6.5	4½	¼	18
¾	.16	2.25	1¾	.27	8.5	5	¼	20
¾	.20	3	2	.15	4.75	5	⅜	31
¾	.23	3.5	2	.18	6			

Lead-pipe Tin'ning. The first attempts in this direction were by Alderson in England, who patented his invention in 1804, which consisted in putting an interior casing of tin pipe within the leaden one.

Dobbs, in 1820, gave a coating of resin to the lead pipe, and then placed it in a mold, a core being also placed in the center, or axial position. Tin was then cast upon it and within it, the two becoming perfectly united. It is then ready for drawing or rolling, whichever may be preferred.

Warner treats the lead pipe with resin, so as to encourage the junction of the tin, and the pipe is then submerged in a bath of melted tin. The pipe may be bent, and thus drawn continuously through the bath, receiving its coat as it passes. If any part, say the outside, is not required to be tinned, such part is covered with lampblack and size. The film of tin may be very thin and does not detract from the flexibility. Tin melts at about 440° Fah. and lead at 612°, but at the point of junction an alloy is formed which melts at a lower temperature and forms a solder.

The purer the water the greater the liability to contract impurity from the lead. Waters containing chlorides, sulphates, or carbonates, throw down insoluble salts of lead. The oxide of lead formed on the pipe protects the metal. Pure waters dissolve the oxide slowly, and the gradual decomposition and removal eat away the pipe.

Owing to galvanic action, the lead is more liable to corrosion in spots not covered by the tin, and therefore an imperfectly tinned pipe is worse than one of lead. To insure the continuity of the coating, Naylor of New York City has patented a process of drawing a sponge saturated with a flux that protects the lead and assists in the adherence of the molten tin.

M. J. Grand's process consists in forming an ingot of tin and lead, the latter metal being on the exterior. A single crucible suffices for melting both metals simultaneously, the tin being uppermost and separated from the lead by an iron diaphragm. The lead is run first into a rapidly revolving mold having a gate in its axis, and while still liquid the tin is let on. The two metals thus become firmly cemented together, the pipe is drawn out in the usual way.

Leads. 1. (*Printing.*) Thin metallic slips used for spacing lines, etc. Invented by Scheeffer about 1465.

2. A flat roof covered with sheet-lead.

Lead-shav'ing Ma-chine'. A machine for cutting lead into shavings, to be used in the manufacture of white-lead.

A series of rotary knives are, by means of a weight and pulleys, brought into contact with the lower surface of a cylindrical ingot of lead, from which they remove shavings proportionate in thickness to the projection of their edges beyond the box in which they are contained.

Lead, Sheet. Sheet-lead was formerly made by melting pig-lead and pouring the metal on a table having a ledge supporting a roller, which passed over the metal and reduced it to an even thickness. The ledge was all around the table, and determined the thickness of the sheet. The modern process is to reduce an ingot of lead by repeated rollings to the required thickness. This is called in England *milled lead.*

The thin sheet-lead which lines tea-chests is said to be made by pouring a quantity of molten lead upon a flat stone; and upon this, while the lead is yet in a fluid state, a corresponding flat stone is suddenly dashed, the superfluous portion, which is squeezed out around the edges, being afterward trimmed off.

Lead-shot. See SHOT.

Lead-sink'er. (*Knitting-machine.*) One of the devices which alternate with the *jack-sinkers* in the depression of the loops between the needles. The lead-sinkers are all attached to one bar, called the sinker-bar, and are raised or lowered all together. See KNITTING-MACHINE.

Leaf. 1. A relatively thin and wide object having a flat surface; as, —

a. The leaf of a book, having a page on each of its opposite sides.

b. A valve or hinged member of a bridge, table, door, shutter, hinge, or screen.

c. One member of a pair of lock-gates.

d. A hinged platform for a ferry or wharf boat.

e. A tooth of a pinion.

f. One section of a fan.

g. A thin sheet of hammered gold.

h. One of the elevating flaps of a rifle-sight.

2. (*Weaving.*) The heddles which are connected to the same shaft, and moved at the same time. (See DRAFT.) The *leaf* is connected with a treadle by a cord. The *number* of leaves is according to the requirements of the pattern, and forms the *set of the draft;* beginning at the back, the *setter* works forward to the front leaf, after which they are again moved in the former succession. Hence we read of a *five-leaf* pattern, an *eight-leaf* pattern. The set of warps which are drawn up by one leaf form the upper part of the *shed* or *shuttle-way.* All the other warps are down for that time, and form the *way* on which the shuttle travels.

Leaf-bridge. A form of drawbridge in which the rising leaf or leaves swing vertically on hinges. One form of *bascule* comes under this description.

Leaf-met'al. 1. Gold-leaf; hammered gold. See GOLD-BEATING.

2. Bronze leaf, or Dutch leaf. The qualities are known as, —

a. Common; soft, reddish color; composed of zinc 1, copper 3.

b. French; harder, less ductile, yellow, larger proportion of zinc.

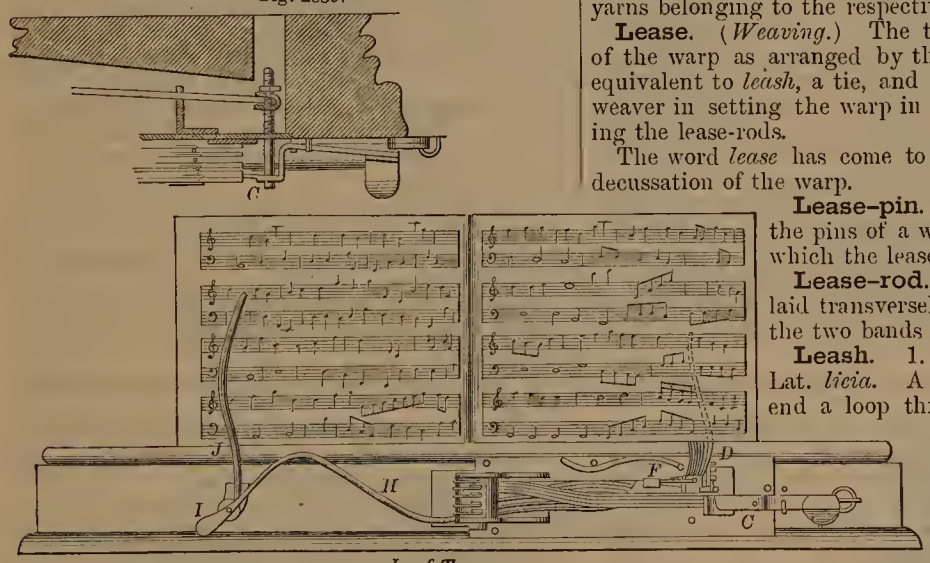
c. Florence; greenish-gold color, still larger proportion of zinc.

d. White leaf; TIN-FOIL (which see).

Leaf-sight. One on the breech of a fire-arm, having a hinged elevating piece (one or more) as a guide for elevation in firing. A *back-sight.*

Leaf-turn'er. A device for turning sheets of music or leaves in a printed book. The fingers *D*

Fig. 2859.



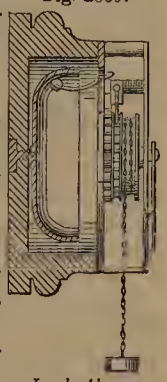
Leaf-Turner.

are inserted between the leaves, and by pressing a key *C* are successively released as required from a catch *F*, allowing a spring to act, carrying the finger from the right to the left hand side of the book, and turning the sheet with it. A free arm *H*, with finger-piece and finger *I J*, serves to keep down the leaves on the left-hand side and to turn back the whole series when a piece of music is finished. The fingers *D* may be pressed downward and held in horizontal position by a catch, so that the leaves may pass freely above them when required.

Leaf-valve. (*Pumping-engine.*) A clack-valve. One hinged or pivoted on one side. A *flap-valve; clack-valve.*

Leak-a'larm. An arrangement by which the accumulation of water in the hold of a vessel is made to sound an alarm to call attention to the leak. It is a regular part of duty on shipboard to sound the pumps, but it is a duty sometimes overlooked. Even when the amount is not dangerous, the accumulation of bilge-water may injure the cargo. See BILGE-WATER ALARM.

Fig. 2860.



Leak-Alarm.

In the example, the water rising in the hold elevates the float, permitting the spring drum to revolve and wind up the chain. This rings the alarm-bell, and moves the index which signifies the depth. As the water falls, the float rewinds the spring.

In another case the staff of a rising float trips an escapement and releases a clapper-alarm.

Leak-In'di-ca-tor. See LEAK-ALARM.

Leak-sig'nal. (*Nautical.*) A device to notify the watch of the rising of water in the hold. See LEAK-ALARM.

Leam. A ditch in a marshy district.

Lean-face. (*Printing.*) Type with unusually thin face-lines.

Lean-to. A shed built against the wall of another structure. A *shed-roof.*

Leap. 1. (*Mining.*) The shifting of a vein. A *fault.*

2. (*Hydraulic.*) A wicker fish-net. A *leap-weel.*

Leap'er. A hollow cylinder with a hook at one end, employed in untwisting old ropes. *Loper.*

Lea-rod. (*Weaving.*) One of the rods placed athwart the warp-threads and separating the *leas*, or yarns belonging to the respective *heddles.*

Lease. (*Weaving.*) The tie around each band of the warp as arranged by the *heck.* The word is equivalent to *leash*, a tie, and forms a guide for the weaver in setting the warp in the loom, and inserting the lease-rods.

The word *lease* has come to signify the plane of decussation of the warp.

Lease-pin. (*Weaving.*) One of the pins of a warping-mill, between which the lease is formed.

Lease-rod. (*Weaving.*) A slat laid transversely across and between the two bands of the warp.

Leash. 1. (*Weaving.*) From Lat. *licia.* A thread having at one end a loop through which a thread of the warp is passed, the other end being fastened to a rod or lever, to which all the other leashes of the same set are also attached. A *heddle.*

2. A leathern thong to hold dogs in couples, to be slipped simultaneously after game.

Leat. An artificial water-course. A mill-race.

Leath'er. The *tanned* or *tawed* skin of an animal.

Tanning was practiced in early ages in some localities, but the references to it are comparatively unfrequent. The Bible has but two notices of it, the girdles wherewith the prophets Elijah and John the Baptist were girded about their loins, — type and antitype.

It is not easy to distinguish in the early mentions of leather what was raw-hide and what was really dressed; even of dressed leather there are many kinds, such as the soft dressing with brains and fat,

the tawing with alum and salt, the tanning with bark extract. The latter is the more complicated process.

Leathern dresses and fringes of thongs have long been common in Africa, being described by Herodotus: "The Libyan women wear goat-skins stript of the hair, fringed at their edges and covered with vermilion; and from these goat-skins the Greeks get their word *Ægis*" (goat harness). IV. 189.

It is believed that tanning and dyeing of leather was first practiced in Libya, and thence carried to Egypt, from whence it was carried across the sea to Greece. Leather was stained and embossed in Egypt. The "*rams' skins dyed red*," mentioned in the Mosaic account of the tabernacle, were of African manufacture. The Africans yet excel in this art. Yellow, red, and black *morocco* yet attest it.

The old national dress of the Persians was a close-fitting tunic and trousers of leather. Leathern helmets, cuirasses, belts, shirts, and buskins were common among the nations in the motley army of Xerxes.

The Libyans wore dresses of leather.

The Paphlagonians leathern buskins and helmets.

The Gordian knot was of leathern thongs, and was summarily cut about 330 B. C.

Alum was used in *tawing* leather by the Saracens.

We do not recollect any account of human hide leather, but as raw-hide or parchment it has been utilized. The doors of Rochester (England) Cathedral were formerly covered with the skins of Danish pirates. The same is reported of the doors of the churches of Hadstock and Copford, Essex, England. In the case of the Hadstock church, the microscope has determined the truth of the tradition, for a portion having been removed and tested, it proved to be the skin of a fair-haired person. Upon the north doors of the cathedral at Worcester was formerly nailed the skin of a person who had sacrilegiously robbed the high altar. The doors date from the end of the fourteenth century, and have been long ago removed, but were lately still to be seen in the crypt.

The use of the human hide as a drum-head is mentioned by Byron, who celebrates the desire of Ziska for a posthumous place at the head of the army of Bohemians who attacked the Emperor Sigismond and defeated him, in retaliation for the treachery of the latter in leaving John Huss to the cruelty of his Romish persecutors. Ziska died of the plague A. D. 1425, and left orders that his skin should be made into a drum-head, "to beat the advance," as Byron says.

The varieties of tanned leather are classed as *hides*, *kips*, and *skins*.

Hides include the skins of the larger animals, as those of cattle and horses. The parts of hides are known as *butts*, *backs*, *flanks*, etc., and form grades of thickness and quality.

Kips are the skins of small and yearling cattle, beyond the size of calf-skins.

Skins include those of calves, deer, pigs, sheep, seals, and some kinds of fur-bearing animals. The latter are usually called pelts or peltry, and of course preserve their hair.

Cattle-skins are the chief source of supply, and it is needless to cite the purposes to which they are applied. The former uses for armor, shields, and boats have decayed, but modern demands far more extensive have arisen. Calf leather is principally used for boot and shoe uppers and for bookbinding.

Sheep-skins are used for a commoner description of bookbinding, bellows, whips, aprons, bags, women's shoes, cushions, and seat-covers, carriage-tops, gloves, leggings, trunks, and many other purposes. Tanned in oil they form a substitute for real chamois leather.

Goat and *kid skins* form the best material for gloves, morocco leather, and ladies' shoes.

Deer and *antelope skins* are dressed in oil (see BUCKSKIN), and are used for gloves and other purposes. Their former use for breeches has become out of date. They afford material for making what now sells as *chamois* leather.

Horse-hides are used as a substitute for those of cattle in some cases, and probably unsuspected by those who buy articles made of this material. Split horse-leather is made up into shoes. Horse-hides are useful for making horse-collars.

Dog-skin is thin, tough, and valuable. It is good in gloves and for *whang*.

Seal-skin is much used as a fur, and, deprived of its hair, forms a good leather.

Hog-skin is yet to be found on saddles, for which it is better adapted than any other leather, being soft and pliable.

Porpoise-skins yield a soft, strong, durable leather, capable of a high finish.

Hippopotamus-hide makes a leather of great thickness, resembling a board when tanned. It is used in the construction of implements used for beetling in bleaching and washing cotton and linen goods.

Alligator-skins are now largely used.

Buffalo, *elephant*, *shark*, and *rhinoceros* skins also find their way to the tan-vat and a market.

1. *Morocco leather* is made from *goat* and *kid* skins, a peculiar grain being given to the surface.

2. *Chamois*, *shammy*, *shamoy*, or *shamois* leather was originally prepared from the skin of the *chamois*, but the skins of other goats, and even of sheep, are now dressed in the soft manner, and furnish skins for polishing, for gloves, and other purposes.

3. *Buff-leather* is so named from the *buffe* or wild bull of Poland and Hungary. It was used for armor, and tanned soft and white. It is yet used for cartridge-boxes and saber-belts in Europe.

4. *Whang* is tough leather made from skins of calves, dogs, ground-hogs, etc. It is used for bag-strings, whip-crackers, belt-lacing, and other occasional purposes.

5. *Russet* is leather finished except the coloring and polishing. In this condition tanned hides are stored, so as to be completed in any desired manner as the demand may suggest.

6. *Roan;* a leather made from sheep-skins in imitation of morocco, except the grain, and used for bookbinding.

7. *Skiver;* a thin split of leather used for hat-linings, etc.

8. *Wash-leather* is a soft-dressed skin suitable for polishing, for specie-bags, and for cleaning metals, plate, and highly polished articles.

9. *Tawed leather* is tanned with alum and salt, soaked in bran-water, dressed with flour of yolk of eggs, softened by rubbing and stretching.

10. *Fair leather* is finished in the natural color imparted by the bark, and not specifically colored.

11. *Russia-leather* is prepared by a careful and prolonged process, and is said to owe its peculiar smell to oil of birch.

12. *Shagreen* is an Oriental production, and resembles parchment. The hides of horses, asses, and camels are used. These are not tanned, but are indented by a covering of seeds and pressure. The dried skins are then sheared. They are then steeped to raise bulbs where the indentations existed.

13. *Enameled leather.* Leather split to the required thickness, and then subjected to two operations; one to make it impermeable to the varnish, and the other to coat it with varnish.

14. *Split leather.* Leather which has been split, the grain from the flesh side, in a machine for that purpose. It is sometimes done to lighten a leather, sometimes to make two thicknesses, both of which are utilized.

15. *Cordovan.* A Spanish leather supposed to be made of goat-skins, tanned and dressed, but often made of split horse-skins.

16. *Oil-leather* is curried in oil. Fish-oil, with or without potassa, is employed in alternation with drying. Fulling, graining, and pummeling are employed, followed by coloring, stretching, and surfacing.

17. *White-leather*, the same as *tawed leather*. The process leaves the leather *white*, differing thus from that tanned by ooze.

18. *Alum-leather.* The skins are tanned white by a solution of alum and salt. This process is adopted in making wash-leathers. See TAWING.

19. *Bazil.* Sheep-skins dyed with bark and used for making slippers.

20. *Jucten.* A name by which Russia leather is known. See RUSSIA LEATHER.

21. *Hungarian leather.* Made by a peculiar process, allied to *tawing*. See page 1142.

22. *Patent leather.* Made by a process of enameling.

23. *Saffian.* A kind of leather prepared in Asiatic Russia from goat-skins.

24. *Maroquin leather.* Same as *saffian*.

Japanned, patent, varnished leather. See ENAMELED LEATHER, *supra*.

See the above under their alphabetical arrangement in the body of the work.

In connection with this subject it may be stated that sales of hides in the American market are made according to the following classification : —

Green hides are those which are sent in just as they come from the animal, never having been salted.

Part cured are those that have been salted, but not long enough to be thoroughly cured.

Green salted are those that have been salted and are thoroughly cured.

Dry flint is a thoroughly dry hide that has not been salted.

Dry salted is a thoroughly dry hide, having been salted while green.

In *green-salted* hides and skins, those weighing less than 8 pounds are called *deacons;* 8 to 14 pounds, *calf;* and 14 to 25 pounds, if plump, *kip*, but if thin and poor are called *runners* or *murrains*, and are sold at two thirds the price of good kip ; all above 25 pounds are called hides.

A green-salted hide is understood to be thoroughly cured, free from salt, dirt, meat, water, horns, tail-bones, and sinews, and before being weighed all such substances are removed, or a proper reduction is made from the weight.

All stag, tainted, and badly scored, grubby, or murrain hides are called damaged, and go at two thirds price, unless they are badly damaged, when they are classed as *glue stock*, and sell at a much lower figure. A deduction of about 10 per cent is made on all branded hides. In dry hides there are other kinds of damaged, such as moth-eaten, sun-burned, or weather-beaten.

For varieties of leather and leather-working tools, see under the list in the next column, *et seq.*

Leather is formed by the combination of the substance of the skin with any other compound which has the property of rendering it imputrescible and elastic. — MUSPRATT.

Tannin is the substance generally employed, and has the effect of solidifying the gelatino-fibrous membranes, so that they are no longer putrescible under the joint influence of warmth, air, and moisture.

The *copperas* process, which impregnates the fiber with an insoluble sub-sulphate of peroxide of iron, is effective in the same way.

The *alum process* is one in which the alumina combines with the tissue. See TAWING.

The supposed reaction is the decomposition of the alum by the salt, producing sub-chloride of aluminium, which unites with the fiber. See TANNING.

Tanned skins are *curried* by soaking, rubbing, and paring (see CURRYING), smeared with *dubbing*, which penetrates the leather as the moisture evaporates ; *waxed*, by rubbing on the flesh side with oil and lampblack ; *black*-sized with a brush or sponge ; *tallowed; slicked* on the flesh-side with a glass-*slicker*.

Leather curried on the *hair* or *grain* side, termed *black on the grain*, is blackened with *iron-liquor* and rubbed with an iron slicker before applying the grease.

The *grain* is raised by a *pommel* or *graining-board*.

The varieties of leather commercially considered are, —

Alum-leather.
American leather.
Backs.
Band-leather.
Bazil.
Belt-leather
Bridle-leather.
Bronze-leather.
Buckskin-leather.
Buffalo.
Buff-leather.
Butts.
Calf-skin.
Chamois-leather.
Cordovan-leather.
Curried leather.
Deer-skin.
Dog-skin.
Dyed leather.
Embossed leather.
Enameled leather.
Fair-leather.
Flint-leather.
Goat-skin.
Green-hides.
Harness-leather.
Hides.
Hog-skin.
Hungarian leather.
Jucten.
Kid.
Kip.
Lamb-skin.
Line-leather.
Linings.
Maroquin.
Oil-leather.
Pad-leather.
Patent-leather.
Roan.
Rough-tanned leather.
Russet-leather.
Russia-leather.
Saddle-leather.
Saffian.
Salted hides.
Seal-skin.
Shagreen.
Sheep-skin
Shoe and boot leather.
Sides.
Skins.
Skirting.
Sole-leather.
Split-leather.
Stamped leather.
Striped leather.
Tawed leather.
Toppings.
Wash-leather.
Waxed leather.
Welt-leather.
Whang.
White leather.

Leather, tools, machines, and appliances for working, excepting harness, for which see SADDLERY.

Alum-leather.
American leather.
Awl.
Bark-pit.
Basane.
Basil.
Bating.
Bawsin.
Beam
Beaming-machine.
Beam-knife.
Belt.
Belt-clasp.
Belt-coupling machine
Belt-cutter.
Belt-fastener.
Belt-lacing.
Belt-punch.
Belt-splicing.
Belt-tightener.
Bend-leather.
Blocking
Bloomer-pit.
Boarding.
Boarding-machine.
Boot.
Boot-channeling machine.
Boot-clamp.
Boot-crimp.
Boot-edge trimmer.
Boot-grooving machine.
Boot-heel cutter.
Boot-holder.
Boot-hook.
Boot-machine.
Boot-seam rubber.
Boot-shank machine.
Boot-stretcher.
Boot-tree.
Boot-ventilator.
Bruising.
Buff-leather.
Burnishing-machine.
Calk.
Chamfering-tool.
Chamois-leather.
Channeling-machine.
Channeling-tool.
Cheveril.
Cleaner.
Clearing-stone.
Clog.
Collar-awl.
Collish.
Cordovan
Crap-leather.

Creaser.
Crimper.
Crimping-clamp.
Crippler.
Currier's knife.
Curry-card.
Currying.
Cutting-board.
Dicing-leather.
Dubbing.
Edge-plane.
Edge tool.
Enameled leather.
Fair-leather.
Fell.
Flank.
Fleshing.
Float.
Flounder.
Forel.
Fore-part iron.
Frizzing.
Fudge wheel.
Fulling-stock.
Gaiter.
Galoche.
Gang-punch.
Grain.
Graining.
Grain-leather.
Grains.
Gullet-hook.
Hair-side.
Handler.
Hand-pegger.
Hand-punch.
Harness.
Heading-knife.
Heel-blank
Heel-breasting machine
Heel-burnishing machine.
Heel-calk.
Heel-cutter
Heel-face dresser.
Heel-iron.
Heel-machine.
Heel-polisher
Heel-polishing machine.
Heel-seat cutter.
Heel-shave.
Heel-tap.
Heel-trimmer.
Herse.
Hide-handler.
Hide-rope.
Hide-scraper.
Hide-shaving machine.
Hide-stretcher.
Hide-worker
Hollow punch.
Horse.
Hose.
Hose-making machine.
Huffling.
Hungarian leather.
Ice-creeper.
Ice-sandal.
Insole.
Instep-stretcher.
Japanned leather.
Jigger.
Jucten.
Kip.
Lap-shaper.
Lap-skiving machine.
Lap-stone.
Last.
Laster.
Last-holder.
Lasting-awl.
Lasting-jack.
Lasting-machine
Lasting-pinchers.
Lasting-tool.
Layer.
Leach.
Leather.
Leather. Artificial
Leather-awl.
Leather-boarding machine.
Leather-buffing.
Leather-chamfering machine.
Leather-cloth.
Leather-corrugating machine.
Leather-creasing machine.
Leather-cutting machine.
Leather-dicing machine.
Leather-dressing machine.
Leather-edging machine.
Leather-embossing machine.
Leather-finishing machine.
Leather-fleshing machine.
Leather-fluting machine.
Leather-glassing machine.
Leather-glueing.
Leather-gouge.
Leather-graining machine.
Leather-grinder.
Leather-hammering machine.
Leathering-jack.
Leather-knife.
Leather-paper.
Leather-pebbling machine.
Leather-piercing machine.
Leather-polisher.
Leather-pressing machine.
Leather-punch.
Leather-punching machine.
Leather-quilting machine.
Leather-raising machine.
Leather-reducing machine.
Leather-roller.
Leather-rolling machine.
Leather-rounding machine.
Leather-scalloping machine.
Leather-scarifying machine.
Leather-scouring machine.
Leather-skiving machine.
Leather-slitting machine
Leather-softener.
Leather-sorting machine
Leather-splitter.
Leather-stamping.
Leather stretcher.
Leather-striping.
Leather-stripping machine.
Leather-stuffer.
Leather-tapering machine.
Leather-washer.
Lift.
Lining.
Lining-apparatus.
Losh-hide.
Mace.
Maroquin leather.
Moccasin.
Moon-knife.
Morocco-leather.
Nailing-machine.
Oil-leather.
Overshoe.
Packing-awl.
Pannuscorium.
Parchment.
Patent-leather.
Pebbling.
Pebbling-machine.
Peg.
Peg-cutter.
Peg-float.
Pegging-awl.
Pegging-jack.
Pegging-machine.
Pep-strip.
Pelt.
Plate leather.
Pommel.
Pooler.
Pricker.
Pricking-wheel.
Pure.
Raising.
Raising-board.
Rand.
Randing-machine.
Raw-hide.
Roan-leather.
Round knife.
Rounding-tool.
Russet-leather.
Russia-leather.
Saddlery.
Saddler's pinchers.
Saffian.
Sandal.
Scalloping-tool.
Screw wire-fastener.
Scribing-compass.
Seal-skin.
Seam-roller.
Seam-set.
Secreting.
Setting-punch.
Sewing-clamp.
Sewing-horse.
Shagreen.
Shammy.
Shank.
Shank-cutter.
Shank-iron.
Shank-laster.
Shank-wheel.
Shoe.
Shoe-clasp.
Shoe-distender.
Shoe-fastener.
Shoe-horn.
Shoe-jack.
Shoe-key.
Shoe-knife.
Shoemaker's pinchers.
Shoe-making machine.
Shoe-nailing machine.
Shoe-peg.
Shoe-shave.
Shoe-stretcher.
Skin-stretcher.
Skiver.
Skiving-machine.
Slicker.
Slicking-gage.
Slicking-machine.
Slippers.
Sole-finishing tool.
Sole-rounding machine.
Sole-shaper.
Soles. Machine for cutting
Sorting-machine.
Split-leather.
Splitting-knife.
Splitting-machine.
Steel.
Stitching-clamp.
Stitching-horse.
Stitch-wheel.
Stock-stone.
Straining-fork.
Straining-reel.
Stretcher.
Stretching-iron.
Striking-knife.
Stuffing.
Tack-claw.
Tag-cutting machine.
Tanning.
Tanning-vat.
Tawing.
Tip.
Trestle.
Trimming-machine.
Turning-machine.
Unhairing.
Unhairing-knife.
Unhairing-machine.
Uppers. Machine for cutting
Vamp.
Vellum.
Wash-leather.
Water-proofing machine.
Waxed ends. Machine for making
Waxing.
Waxing thread. Machine for
Welt.
Welt-guide.
Welt-knife.
Welt-machine.
Welt-trimmer.
Whang.
White-leather.
Whitening.
Wrinkling-machine.
Yufts.

Leath'er, Ar-ti-fi'cial. Cloth treated with oils, pigments, and gums, to give it a shining, water-proof surface.

The materials used are : —

Linseed and resin oil.

Glue, glycerine, boiled linseed-oil, caoutchouc, coloring matter ; impressed with a design while hot, to imitate morocco, afterwards treated with a solution of chrome alum or copperas.

Turpentine and naphtha.

Lampblack.

Caoutchouc and gutta-percha.

Stearine, gelatine, leather parings.

Bark infusions, alum.

In various combinations and proportions.

Gunby's artificial leather, 1824 (English), cotton, linen, woolen, or felt cloth is coated with the following composition : —

Common glue-size, 8 parts ; boiled linseed-oil, 4 parts ; lampblack, 1 part ; white-lead, 2 parts ; pipe-clay, 2 parts.

This is to be melted and well mixed. The cloth is stretched and the composition spread by a palette-knife. Dry by a stove ; repeat the composition and dry. Four or five coats may be thus applied. Varnish to give a gloss.

Hancock's artificial leather (English). A card or wide sliver of flax or cotton fibers is condensed so as to resemble a felted material. This is treated with liquid caoutchouc laid on by a spatula. It is then rolled, coated with resin, and rerolled.

Bonneville's artificial leather is made from leather cuttings, shavings, and parings, by reducing while in a dry state to powder. This powder is next mixed with a solution of india-rubber, with or without a solution of gum-lac, or of marine glue, to a suitable consistence. When partially dried, which process is effected by straining on wire-cloth or perforated metal, the sheets or slabs of artificial leather are pressed between rollers, and, if required, are ornamented in any suitable way.

In general terms, artificial leather may be stated

to be any kind of cloth or paper immersed in a solution of the following ingredients, or any of them in combination : Gelatine, glue, soap, oil, glycerine, saccharine matter, water, clay, aluminous earth, plaster, ground slate or stone, cement, any oxide of metal, or pigment.

Or any kind of fabric or paper in a composition embracing any of the gums or resins, — dextrine, caseine, albumen, gluten, or starch.

The following ingredients are also used : tannic-acid, cutchin, gallic acid, boracic acid, alum, borax, chrome alum. See also LEATHER-PAPER.

Leath'er-awl. 1. A shoemaker's piercing-tool for stitching or lasting. See AWL.

2. A tool for lacing belts. In one case it has a broad point, which fades away into two cutting edges on a conical scoop-shaped blade, which make a clean, circular cut of the desired size within the capacity of the blade.

Or it has an eye-point to carry the lacing through.

Leath'er-board. (*Leather.*) A composition of leather scraps and paper material, ground together and rolled out into sheets.

Leath'er-board'ing Ma-chine'. A machine in which tanned leather may be pressed and rubbed to supple and soften it, so as to fit it for the subsequent operations, which are generally comprised under the term *finishing*. See BOARDING-MACHINE, Figs. 740, 741.

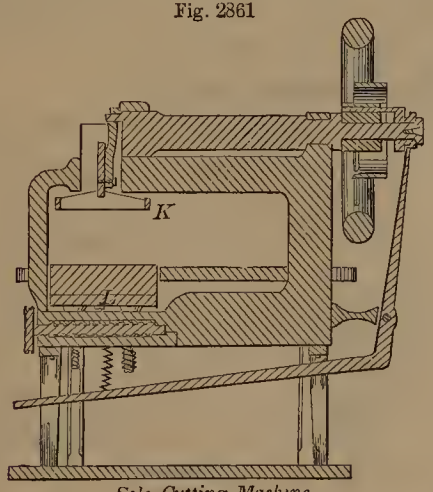
Leath'er-buff'ing Ma-chine'. A machine in which the surface of leather is reduced to a smooth but not polished surface, the face being left with a slight nap, velvety, like buff leather.

Leath'er-cham'fer-ing Ma-chine'. A machine for beveling the edges of straps or strips of leather, giving a feather or thinned edge thereto. It is a skiving process, and is usually performed on a *skiving* or *shaving* machine.

Leath'er-cloth. (*Fabric.*) A fabric covered with a water-proof composition, usually having a polished surface. It generally consists of a paint or a varnish, sometimes the former with a covering coat of the latter. The changes in menstruums, resins, pigments, and coarse and cheap materials, which are added for quantity, are so various that room cannot be afforded for stating them at length. See ENAMELED CLOTH ; LEATHER, ARTIFICIAL.

Leath'er-cor'ru-gat'ing Ma-chine'. A machine in which leather is crimped, corrugated, or fluted for certain purposes in manufactures. It is usually done by passing between a fluted and a plain roller and drying while the indentations are preserved ; or it may be done by passing the leather while damp between plates or dies of the requisite form.

Fig. 2861



Sole-Cutting Machine.

Leath'er-creas'ing Ma-chine'. A machine for ornamenting the edges of leather straps by passing between rollers indented with the required patterns in intaglio and cameo.

Leath'er-cut'ting Ma-chine'. A machine for cutting leather into shapes for shoe-stock or other purposes ; sole-leather into soles and lifts, for instance. The sole-leather is placed on the adjustable table *L* beneath the platen *K*, and a die which is of the shape of the piece to be cut is placed upon the leather. Pressure on the treadle throws the friction-clutch into operation, and the cam-shaft is rotated, depressing the platen upon the die and cutting a sole from the leather.

Leath'er-dic'ing. Another name for *leather dressing* or *finishing* or *polishing*. Also known as *glassing*, the tool for the purpose being usually a slip of glass set in the grooved edge of a wooden strip which forms the handle.

Leath'er-dress'ing Ma-chine'. A machine in which tanned and curried leather undergoes the finishing operations which improve its texture and surface. The term is somewhat indefinite, as *boarding* or *graining*, *scouring*, *coloring*, and *glassing* or *polishing* are or may be all performed upon the leather in course. See under those heads.

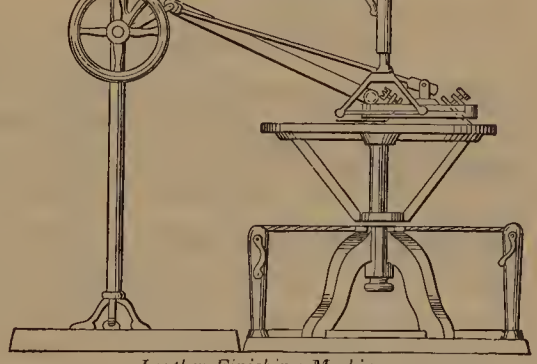
Leath'er-em-boss'ing Ma-chine'. A press or roller having an engraved pattern or one otherwise procured by casting or electro-plating, and which is impressed upon leather in a damp state. Schroth's English patent, 1839, describes dies of type-metal or a fusible alloy containing bismuth ; the leather is beaten soft in water, wrung, pressed, rolled, and fulled, until it becomes quite supple. It is then laid on the die and driven in by a bone tool or by a press. It is allowed to dry *in situ*. See also LEATHER-PEBBLING MACHINE.

Leath'er Feath'er-edg'ing Ma-chine'. One for skiving off the edge of a piece or strip of leather, gradually thinning it toward the edge, which is left comparatively sharp. See LEATHER-SKIVING MACHINE.

Leath'er-fin'ish-ing Ma-chine'. A machine in which tanned and curried leather is dressed to give it the required texture and surface finish.

In the example, the leather is placed on the table, which has horizontal and rotary movement

Fig. 2862.



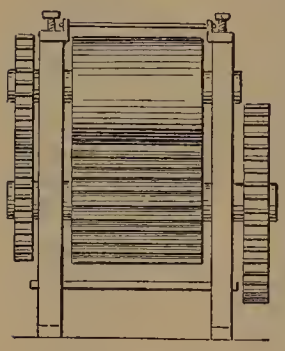
Leather-Finishing Machine.

beneath the reciprocating "plane stock," which carries two slickers and a circular knife, which act upon the surface of the leather. The term is somewhat indefinite, and may include boarding, graining, glassing, polishing, etc.

Leath'er-flesh'ing Ma-chine'. A machine for reducing the thickness of leather by shaving off a portion of the flesh side.

Leath'er-flut'ing Ma-chine'. A machine for corrugating leather, as in the example, in which the leather when damp is run between a fluted and a plain roller, and afterward dried between heated plates of similar conformation. Sole-leather so prepared is used for work of a cellular character.

Fig. 2863.



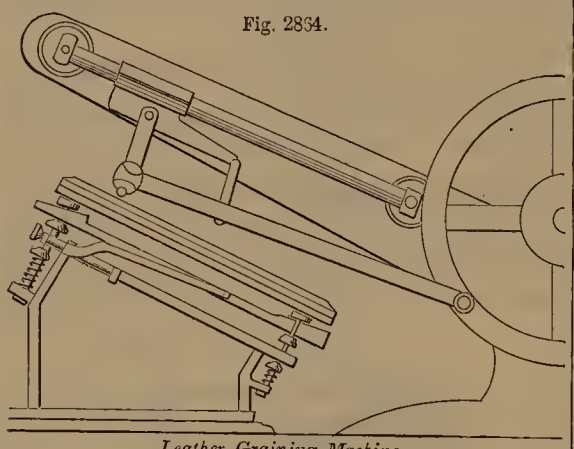
Fluting-Machine.

Leath'er-glass'ing Ma-chine'. One in which the leather is dressed or polished in a machine which has a "glassing-tool" attached to a suspended arm, which is vibrated by crank and pitman over the leather, which rests on a yielding bed below, curved to the arc of the swinging tool. The glassing-tool has an elastic bearing at its pivot to enable it to yield to inequalities. See LEATHER-POLISHING MACHINE.

Leath'er-glu'ing Ma-chine'. A machine for holding firmly together the scarfed ends of united sections of leather belting. See GLUING-PRESS, in which the contiguous, beveled, cemented ends of the leather strips are clamped between the bed-piece and the face of the pivoted platen.

In Fig. 2864, the leather is laid upon an inclined table, vertically adjustable by inclines and supported by springs which give a certain elasticity to the bed.

Fig. 2864.



Leather-Graining Machine.

The graining-tool is reciprocated above the leather, a crank acting upon a pitman and arm, the latter depending from the sliding carriage.

Leath'er-gouge. (*Saddlery.*) A tool used to cut channels in leather for receiving the thread of a line of stitches.

Leath'er-grain'ing Ma-chine'. A machine in which tanned hides may be boarded, grained, or softened, to render them flexible, that they may be in the supple and absorbent condition fit for the other finishing processes. See BOARDING-MACHINE, Figs. 740, 741, *ante*.

Leath'er-grind'er. A machine for reducing scraps of leather to shreds, in order that the material may be made into washers, in-soles, and heels for shoes. The machine has a feeding-box, a follower or piston, by which the shreds are kept in a compact mass while being acted upon by a set of revolving tearing teeth. A set of revolving clearers act to clear out the tearing teeth, and a contrivance is used for throwing streams of water upon the teeth.

Leath'er-ham'mer-ing Ma-chine'. A machine of the nature of a drop-hammer or *oliver*, for compacting leather for shoe-soles.

Leath'er-knife. The leather-cutter's knife with a curved blade seems to have undergone no special change for three thousand years. The figure in the accompanying cut is from a group on a building at Thebes; it represents men cutting out harness.

Fig 2865.

Leather-Cutting (Thebes).

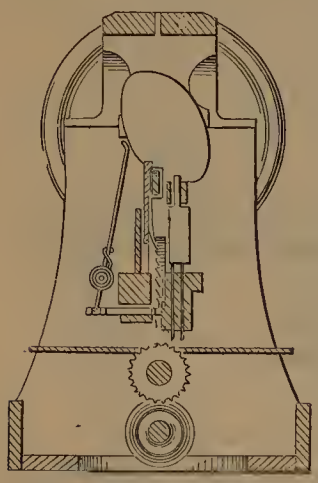
Leath'er-pa'per. A mode of preparing paper, in which it is made to assume the appearance of leather. The Japanese process is about as follows: Sheets are damped and laid in pairs between sheets of varnished paper, which have a crinkled grain running in one direction. They are then wound upon a roller, the grain of the pattern of the paper derived from the crinkled sheets between which it was laid running around the roller. The roller being slipped out, the roll of paper is slipped into a cylinder and subjected to endwise pressure, reducing it to three quarters its original length. It is then unwrapped and pressed to remove the deep marks. It is then again rolled, colored, oiled, varnished, pressed, and dried. By means of parallel or cross lines on the rollers, the upper surface of the paper is made to resemble leather exactly in all its varieties. The paper being pressed to one third, or even to one half, its original thickness, and the passage through the rollers giving it a fine-grained appearance, makes it valuable to picture-printers, as the surface has the appearance of crêpe silk.

There is another variety of leather-paper which is smooth and transparent, resembling hog-skin very much. This is manufactured by a process of hammering, and is the higher priced.

Leath'er-peb'bling Ma-chine'. One in which a fancy surface is given to dressed leather, resembling morocco, levant, hog-skin, or other fancy style. The leather is passed upon a bed beneath a roller having the desired pattern. The pattern is given by soft metal, which has been cast upon an original surface of the required character (see LEATHER-EMBOSSING), or the pattern of the roller is obtained by taking an electrotype copy of some selected piece of leather and transferring to the roller.

Leath'er-pierc'ing Ma-chine'. A machine for stabbing objects of leather, as, for instance, straps or soles for stitching. In the example, the leather is fed first to the piercing-tool, and then to the die which forces the wire into the openings, the two operations being performed simultaneously in consecutive openings. The wire is fed by a cam

Fig 2866.



Leather-Piercing Machine.

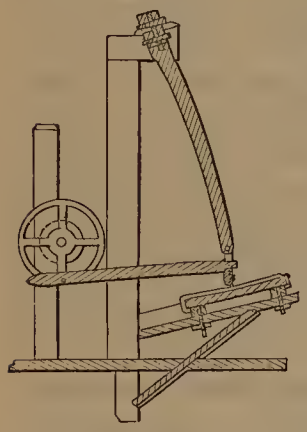
acting on feed-wheels, is cut by a chisel, and placed in proper position for the driving-die.

Leath'er-pol'isher. A machine in which the surface of leather is condensed and polished beneath a reciprocating slicking-tool.

The leather is placed upon a table whose top is curved to agree with the arc of oscillation of the tool. The glassing-tool has an elastic bearing at its pivot, which enables it to yield to inequalities, and it is reciprocated by connection to a wrist on a hand-wheel.

Leath'er-press'ing Ma-chine'. A machine in which leather previously damped, and in some cases after receiving a preliminary local stretching, is pressed into form between corrugated or salient and receding surfaces, as the case may warrant. Used for making harness-pads and many other purposes.

Fig. 2867.



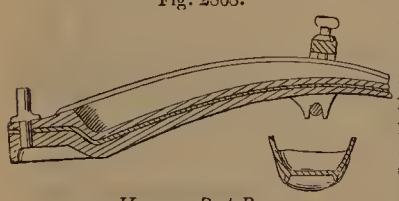
Leather-Polishing Machine.

In the example, the pad-holder consists of a thin shell of cast-iron, having on its bottom two ribs to form a support for the holder when clamped on the stitching-horse.

Leath'er-punch. A hand-tool for making holes in leather for the insertion of eyelets or lacing.

Fig. 2869 has a lock-plate pivoted by its shank within the jaw of the punch, and is operated by a key-like handle, so that it may be made to hold and release different cutting-tools. The folded end of the strap is operated upon by the cutter, and an oblong opening is formed thereby.

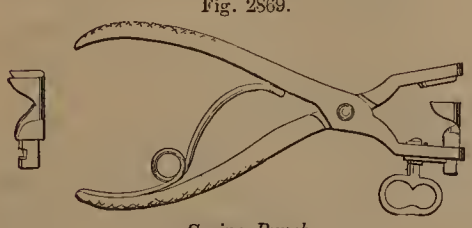
Fig. 2868.



Harness-Pad Press.

Fig. 2870 is a belt-punch, in which the jaws and

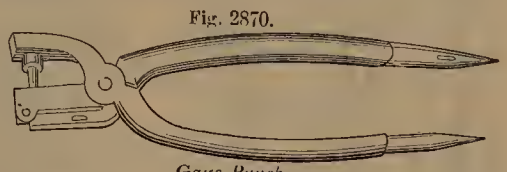
Fig. 2869.



Spring-Punch.

punching-devices are combined with a knife-blade, a punch, a needle, and an awl, arranged with reference to each other upon the respective portions.

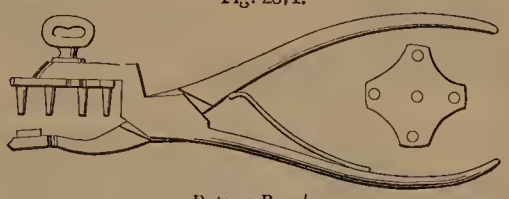
Fig. 2870.



Gage-Punch.

Fig. 2871 is a spring-punch, having a series of tubular cutters which differ in size, and either of which may be readily brought into requisition.

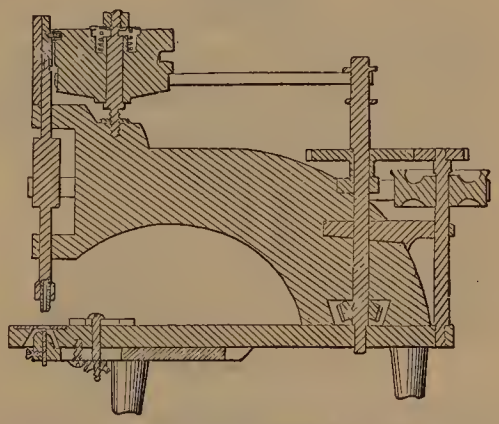
Fig. 2871.



Rotary Punch.

Leath'er-punch'ing Ma-chine'. A machine in which punch and die are automatically operated, while the material is fed between them by hand or otherwise. The punch has an annular sleeve-die which makes a circular imprint around the opening, a pin beneath forcing the pellet into the throat of the die. The punch and die-stock are reciprocated by a wrist and cam-wheel, a certain elasticity of the latter on its shaft providing for the requirements of

Fig. 2872.



Leather-Punching Machine.

varying thicknesses of leather. The punch is revolved by band and wheel.

Leath'er-quilt'ing Ma-chine'. A form of sewing-machine.

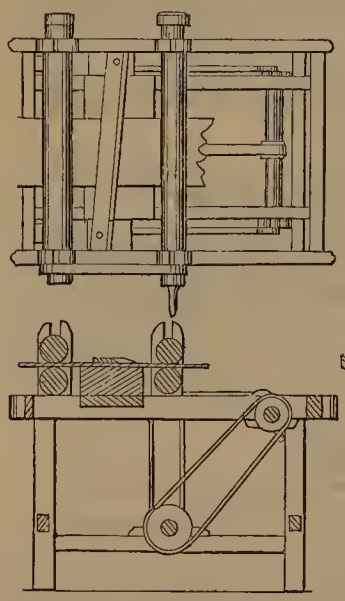
Leath'er-rais'ing Ma-chine'. (*Harness.*) A machine for giving raised and ornamented or beaded edges to straps. A *leather-creasing machine.*

Leath'er-re-duc'ing Ma-chine'. A machine to shave or reduce the inequalities of the flesh side and bring the piece of leather to a uniform thickness.

In the example, the machine has pairs of receiving and delivering rolls, and between them a flat reciprocating knife, which is set obliquely across the path of the leather and thus delivers a draw-cut.

Leath'er-roll'ing Ma-chine'. A machine to compress and harden leather, instead of hammering it. The journals of the lower or pressure roller are mounted in a movable lever frame, which is provided on the under side of either end with projec-

Fig. 2873.

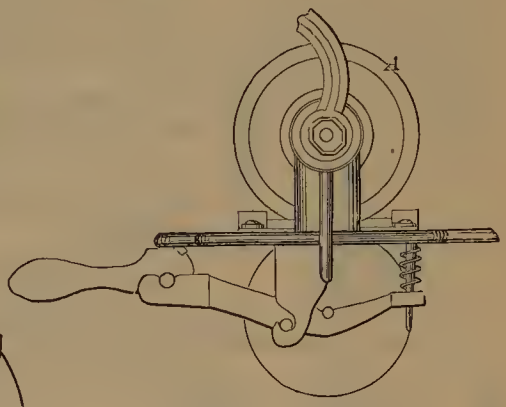


Leather-Reducing Machine.

Fig. 2874.

Leather-Rolling Machine.

Fig. 2877.

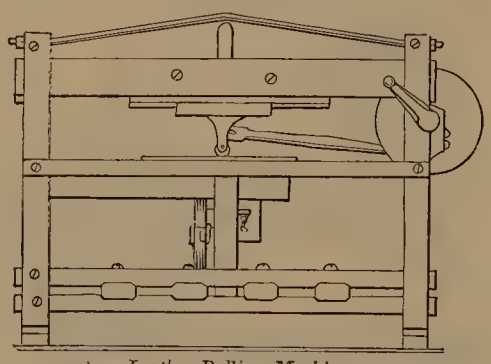


Leather-Scalloping Machine.

tions resting upon joints, which are supported upon the central portion of a cross-piece in the main frame, in such manner as to operate with the lever frame like a toggle-joint, in addition to the usual compound lever employed for moving the pressure-roller.

In another machine, the skin of leather is placed on the table, which is raised more or less by toggle-levers, to regulate the pressure of the roller. The

Fig 2875.

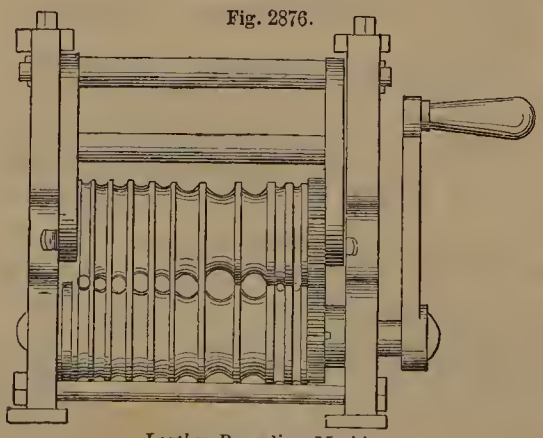


Leather-Rolling Machine.

roller is journaled to a slide reciprocated by connection to a crank. The tool is a steel roller or glass edge.

Leath'er-round'ing Ma-chine'. (*Harness-making.*) A machine for making round lines or whip-eovers from flat strips of leather, by gradually turning the edges inward and strongly compressing the material. In the example, the rolls have graduated eireular apertures between them, and the upper one is earried in a frame pivoted so as to be adjustable in distance from the other roller. The action is somewhat similar to that of rolling gun-barrels from skelps.

Fig. 2876.

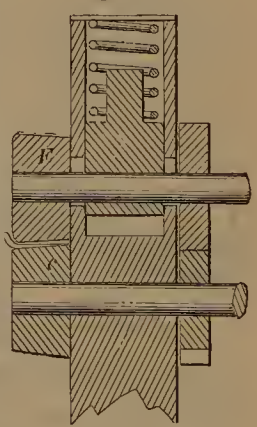


Leather-Rounding Machine.

Leath'er-scal'lop-ing Ma-chine'. A machine for giving a wavy outline to the edges of leather straps to be used in making ornamental harness, and for other purposes. The example has a pair of wavy-edged disks set at any required distance apart, according to the width of strap operated upon. In the drawing, the scalloped shape of the disk *A* is not apparent, and the farther disk is hidden by the near one. The pressure of the bed-roller against the scalloped disks is increased by a cam-lever at one end of the supporting lever of the bed-roller. Motion is given to the scalloped disks by a winch.

Leath'er-scarf'ing Ma-chine'. One for beveling the edges of leather, slanting off the thickness to enable pieces to be united by a scarf-joint. In the example, the stationary horizontal cutter, opposed to the space between the rollers *E c*, cuts the leather obliquely as it passes through between them.

Fig. 2878.



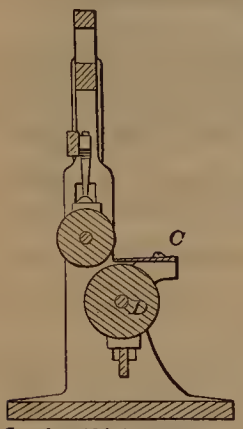
Leather-Scarfing Machine.

Scarfing, *skiving*, *chamfering*, and *feather-edging* are synonymous terms; the first two more often applied to leather generally, and the last to *beveling* leather for soles, leaving a blunt edge. The lap-seam uniting the vamp and quarters, in fine work, is sometimes formed with skived edges to avoid a ridge. In coarse work, as plow-shoes, the leather about the ankle-opening is chamfered from the inside to prevent chafing. Leather is also skived for making lap-joints in round work and belting.

Leath'er-scour'ing Ma-chine'. A form of leather-finishing machine, or rather one of the modes of operation of such a machine, which is usually adapted for *scouring*, *graining*, or *boarding* or *polishing*, according to the character of the tool which is brought upon the skin under treatment. See LEATHER-FINISHING MACHINE.

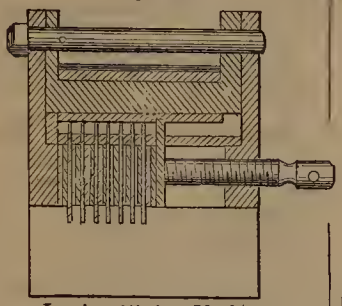
Leath'er-skiv'ing Ma-chine'. A machine for shaving leather to a thickness, skiving off a portion of the flesh side. In the illustration, the leather is passed obliquely upward between the rollers and against the edge of the knife *C*, whose

Fig. 2879.



Leather-Skiving Machine.

Fig. 2880.



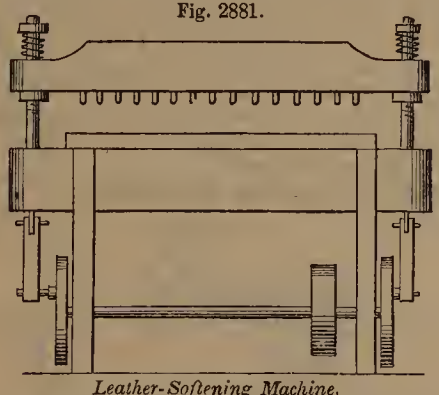
Leather-Slitting Machine.

position relatively to the adjustable roller *D* determines the thickness of the leather which passes between the knife and roller, the skive passing above the knife.

Leath'er-slit'ting Ma-chine'. A machine used principally by harness-makers and saddlers, for cutting leather into straps; the knives are adjustable in distance from each other, to fit them to form straps of different widths. In the example, a series of knives is placed between guides separated by plates and clamped by a set-screw. A segmental, leather-covered frame is hung so as to be brought down over the cutters or thrown up therefrom. The leather, after reduction to the proper thickness, is placed on the cutters and the block brought down thereon. The leather is then drawn through between the gang of cutters and the segmental plate above, which form a surface against which the knives cut.

Leath'er-soft'en-er. A machine for working dry hides or leather, to make them flexible, and enable them to be worked without breaking. It is a preliminary to the operations of tanning dry hides or of finishing processes with tanned skins. The machine has corrugated rollers which press and extend the leather, or it acts by pounding. In the

Fig. 2881.

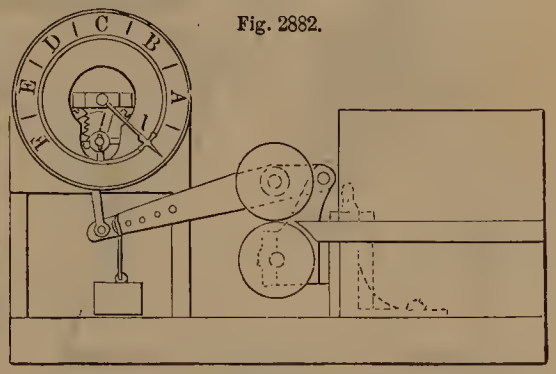


Leather-Softening Machine.

example, the bed has a series of depressions, and the cross-head a series of matching projections, between which the leather is passed. The cross-head has vertical reciprocation from two cranks on a rotating shaft beneath.

Leath'er-sort'ing Ma-chine'. A machine in which leather strips are assorted according to thickness. In the example, the strips of leather cut from the skin to form shoe-binding are thus sorted. Connected with the contacting surfaces, between which

Fig. 2882.



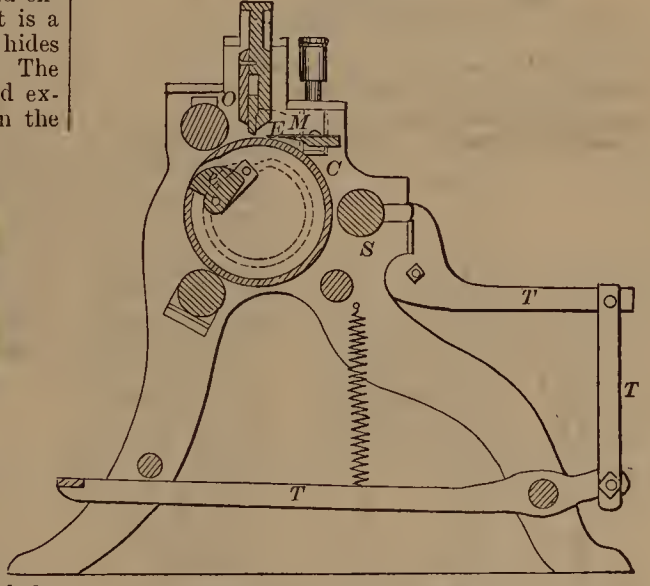
Leather-Sorting Machine.

the strips pass, is mechanism indicating by a finger and dial the thickness of the passing strip.

Leath'er-split'ting Ma-chine'. An apparatus for dividing leather into two or more layers. Split leather is much used in making boots and shoes of cheap quality. The advantage in using the splitting-machine is that the quantity of leather surface is doubled. By splitting so as to preserve the *grain side*, one sheet of very fair leather may be obtained, while the other (*skiving*) is fit for trunk-covers, etc. The machine consists essentially of one or more rollers, which draw the leather against the edge of a horizontally arranged long knife, by which it is divided, one half passing above and the other below the knife.

In Stearns's machine (Fig. 2883), the leather is drawn forward by the tooth *e* on the carrying cylinder *C*, passes between the roller *O* and presser-bar *E*, and after being split by the adjustable knife *M* is drawn between the carrying cylinder and the roller *S*, in order to compress and smooth it; the amount of pressure being governed by the treadle and levers *T T T*.

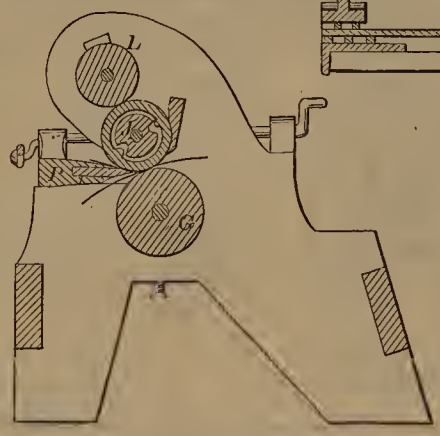
Fig. 2883.



Stearns's Leather-Splitting Machine.

In Marden's machine (Fig. 2884), the leather is drawn to the knife *P* between the rollers *G J*, the latter gears loosely with both the rolls *G L*, and its bearings are elongated vertically, that it may rise and fall to admit leather of varying thickness.

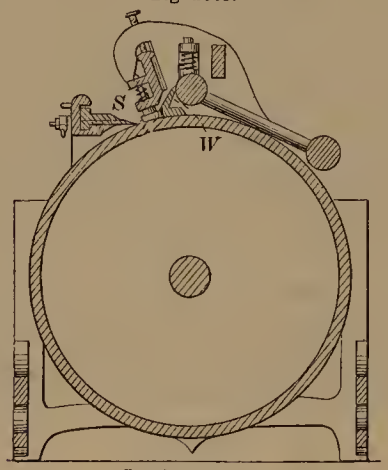
Fig. 2884.



Marden's Leather-Splitter.

Fig. 2885, the knife *S* reciprocates longitudinally, the cylinder is adjustable, and the leather is held down by a foot on the presser-bar *W*.

Fig. 2885.

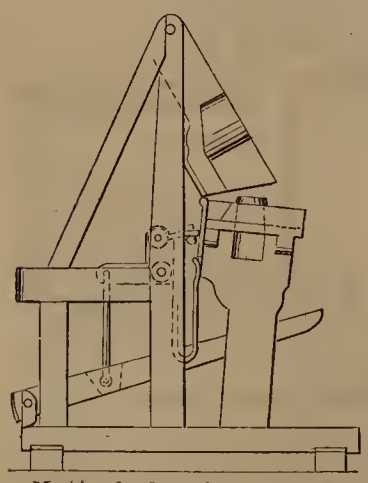


Leather-Splitter.

In another machine, the leather is split by an endless, knife-edged, steel band, sharpened by an emery-wheel while running.

Leath'er-stamp. A machine for stamping and shaping leather. The die and follower are jointed to form a toggle. The lever operates the bell-crank lever and toggle-joint, and brings the follower down upon the knife or die-plate, and thereby cuts the leather to the shape of the face of the die.

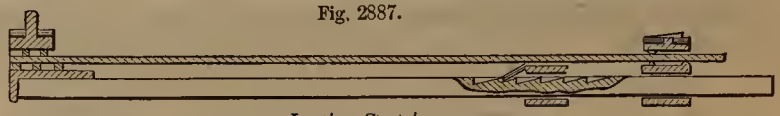
Fig. 2886.



Machine for Stamping and Shaving Leather.

Leath'er-stretch'er. A frame in which a side of leather is stretched, that it may dry flat. Some frames have tenter-hooks, others are made with sides expanded by wedges, like a painter's canvas. In the example, the bar has one fixed and one movable clamp, and between them is a slide-bar having a pawl to catch in a ratchet in the main bar, and rubber springs acting on the movable clamp.

Fig. 2887.



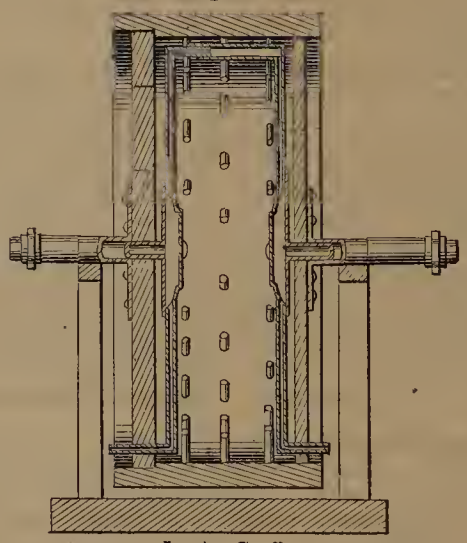
Leather-Stretcher.

Leath'er-strip'ing. (*Shoemaking.*) A machine for marking binding-leather with stripes to be cut into strips for shoe-binding, etc.

Leath'er-strip'ping Ma-chine'. A machine for cutting sides of leather into strips of uniform width, from which soles and heels are afterwards to be punched by hand or by power.

Leath'er-stuff'er. A machine or a revolving chamber in which hides are made supple and stuffed with dubbing, to make them soft and pliable. It is the equivalent of the breaking-machine, which is used to break dried hides before tanning. The hand-process is to rub and bend them gently until the fibers yield and gradually absorb moisture. In the stuffer shown in the figure, the heating-chambers of the cylinder are placed inside the heads, and receive steam through the tubular gudgeons. The steam passes off through radial pipes. The hides tumble about in the box, become softened by heat and impact, and absorb the dubbing, which is tallow mixed with fish-oil or petroleum.

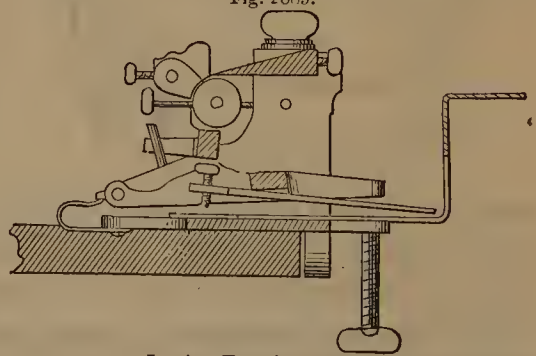
Fig. 2888.



Leather-Stuffer.

Leath'er-ta'per-ing Ma-chine'. A machine

Fig. 2889.

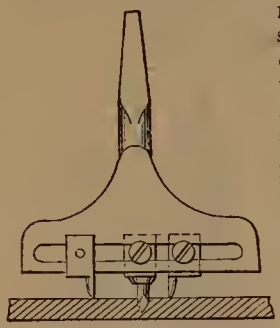


Leather-Tapering Machine.

in which leather straps may be shaved or beveled toward the end. Such a machine is arranged so as to be adapted to any width or thickness of leather. In the example, the cutter is hinged at one end to a stationary frame, and is vertically adjustable at the other end. The axis of the friction-roller connected with the vertically adjustable frame is directly under the cutting-edge of the knife. The roller is supported on a sliding frame that is gradually raised toward the knife, for tapering the ends of leather belts.

Leath'er-wash'er. Tools for cutting leather-washers are on the principle of the trepan or the annular auger. The example shows one in which the cutters are both adjustable relatively to the center-pin, so as to cut a washer of any size with a hole of any size. The washers are cut by revolving or turning the tool upon the center-pin, in the material from which the washer is to be made. The tool is held in a brace.

Fig. 2890.



Washer-Cutter.

Leav'en. Sour dough, for producing fermentation in a quantity of freshly made dough. A substitute for *yeast*. See BREAD.

Le-clanche' Bat'ter-y. A form of galvanic battery invented by Georges Lionel Leclanche, a French electrician.

Two forms of battery are known by this name: —

1. A porous cup in which the carbon or − element is placed, the remaining space in the cup being filled with a mixture of peroxide of manganese, chlorohydrate of ammonia, and sawdust. This cup is placed in a cell in which the zinc or + element is also placed. One liquid is used containing a salt which has no chemical action on the peroxide of manganese, but which is capable, by its electrolytical decomposition, of rendering soluble the oxides of manganese. The salt commonly used in the exciting liquid is muriate of ammonia. The battery-cup is hermetically sealed for convenience of transportation. Patented August 23, 1867. Reissued February 17, 1874.

2. A plate of copper with wire attached is covered in the jar with powdered carbonate of copper; over this is placed a stratum of sand, in which is imbedded the zinc with wire attached. The whole is then saturated with a solution of chlorohydrate of ammonia. June 5, 1866. Reissued February 17, 1874.

Lec'tern. (*Architecture.*) The reader's desk in a church.

Ledge. 1. (*Architecture.*) A small molding, as the Doric drop-ledge.

2. (*Joinery.*) *a.* A piece against which something rests; as the batten on the back of a door, the fillet against which a door closes, etc.

b. A shelf.

3. (*Mining.*) A stratum of metal-bearing rock.

4. (*Shipbuilding.*) A thwart-ship piece in the deck-framing. See SHELF-PIECE.

A support for the decks, parallel to and intermediate between the beams. See HEAD-LEDGE.

5. (*Printing.*) A piece of furniture; a stick used in wedging up.

Ledg'er. 1. (*Scaffolding.*) A horizontal pole, parallel to the walls, lashed to the *standards* or vertical poles, and supporting the *putlogs* on which the boards of the bricklayers' scaffold rest.

2. (*Masonry.*) A large, flat cap-stone, over a tomb for instance.

Ledg'er-blade. The stationary blade with a rectilinear edge, placed as a tangent to the spirally bladed cylinder, by which cloth is shorn and the nap reduced to a length.

Another form of cloth-shearing machine has a semicircular ledger-blade, and a large revolving-wheel containing 8 small cutting-disks, revolved by planetary pinions, and acting as shears in connection with the edge of the ledger-blade. See CLOTH-SHEARING MACHINE.

Ledg'ment. A string-course, or horizontal suite of moldings, such as the base-moldings of a building.

Lee. (*Nautical.*) The side of a ship opposite to that from which the wind blows; the sheltered side. The *lee-way* of a vessel is the amount of its drifting to *leeward*.

Lee-board. (*Nautical.*) A board lowered on the lee side of a flat-bottomed vessel to act as a temporary keel in avoiding lee-way, preventing the vessel drifting to leeward.

A *center-board* is a lee-board, raised and lowered in a water-tight well amidships. See CENTER-BOARD; SLIDING-KEEL.

Leech. (*Nautical.*) The side edge of a square sail. The foremost edge (for the time being) is the *luff* or *weather-leech*.

In a *fore-and-aft* sail, the after edge is the *leech*.

Leech, Ar-ti-fi'cial. (*Surgical.*) A light glass tube from which the air is expelled by the vapor of ether, and whose mouth is then applied to a previously scarified portion of the body.

To expel the air from a tube, a few drops of ether are poured into it, and it is then immersed as far as the mouth in hot water until the ether boils briskly. The mouth of the tube is then applied to the skin,

Fig. 2891.

Artificial Leech and Scarifier.

and held for an instant, when it will be found to be firmly attached, and can be left to itself. Each tube will draw about two ounces of blood. For uterine practice they are made long enough to be applied through a speculum.

The scarifier is simply a tube one eighth inch in diameter, having a cutting-edge at one extremity. By a simple device this is made to rotate rapidly, making, when applied to the skin, a circular incision, the depth of which is regulated by a gage.

In the cut, *a* represents the buttons by turning which the instrument is wound up, *d* the trigger by which the spring is released, *c* the cutting-edge, and *b* the gage for regulating the depth of the incision.

Themison, a physician of Laodicea who flourished a little before Celsus (first century A. D.), mentions the use of leeches.

Michael Servetus, burnt at Geneva in 1553, announced and explained the circulation of the blood, correctly describing the action of the heart, the duty of the arteries and the veins, and the influence of the lungs. He correctly describes the single circulation, and is the first to employ the term of *anastomosis* to express the communication between the veins and arteries in the tissues. See Servetus, "De Christianissimi Restitutione." See LANCET.

Leech-line. (*Nautical.*) A line attached to the leech-rope on the edge of a sail, and passing up through a block on the yard, to haul on the leech; as the *bunt* and *leech lines*, the *preventer leech-line*.

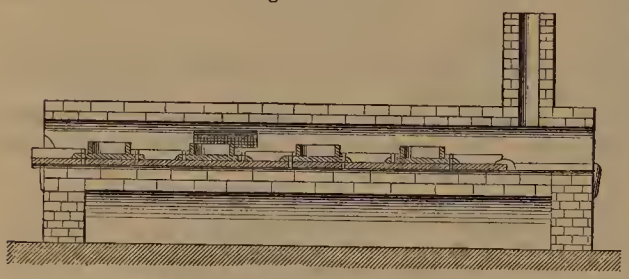
Leech-rope. (*Nautical.*) That part of a bolt-rope along the vertical edge of a sail. The *leeches* are hauled by *leech-lines*, which pass up through blocks on the yards, and *brail* up the sail.

Lee'fange. (*Nautical.*) An iron across a deck or on the taffrail, for the sheet of a fore-and-aft sail to slip on in tacking.

Leer. The annealing chamber or arch of a glass manufactory. *Lier.*

It is sometimes a simple oven, or it may be a long chamber through which the ware is pushed in trays, the period of passage being sufficient for the annealing operation. In the example, the heat is received

Fig. 2892.



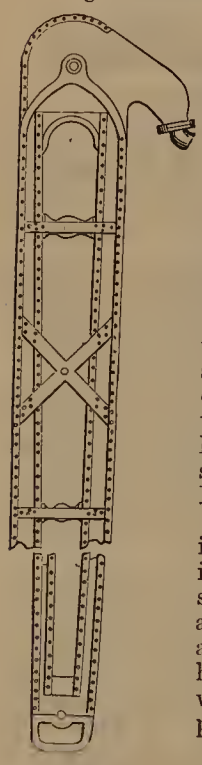
Leer.

at an opening between the points of reception and discharge, and is graduated toward both ends.

Left-hand Rope. Rope laid up and twisted "against the sun," as it is termed. *Water-laid* rope.

Left-hand'ed Screw. A screw whose threads advance "against the sun," that is, from right to left. This is the opposite to the common, or *right-handed* screw, which is operated by turning it in the direction of the hands of a watch.

Fig. 2893.



Elevator-Leg.

Leg. 1. (*Elevator.*) The movable dependent case containing the lower end of the belt of iron buckets of a grain-elevator. See ELEVATOR.

2. (*Furniture.*) A support of a table, chair, stove, etc.

3. One limb of a compass. The legs are called *pencil, pen, wheel, extension, reversible, point* legs, etc., according to their furnishing or adaptation.

Leg, Ar-ti-fi'cial. A prosthetic lower limb, which is made specially for amputations above or below the knee. The form is usually in imitation of the natural leg, but sometimes it is made skeleton-wise for lightness, as in Fig. 2894.

Among the materials used for its structure are raw-hide, which is very light and stiff for its strength; splints crossing at right angles and glued together; bands and strips of wood interlaced; hollow shell of wood; basket-work of wire; vulcanite; gutta-percha.

"The cripple may go out on the Sabbath with his wooden leg: such is the dictum of Rabbi Meir; but Rabbi José prohibits it." — MISHNA.

The compass-joint for the knee, and the ball-and-socket joint for the ankle, are described in Pott's English patent, 1801.

Fig. 2894 is an artificial leg adapted for leg amputation at the upper third, where the knee rests in a

Fig. 2894.

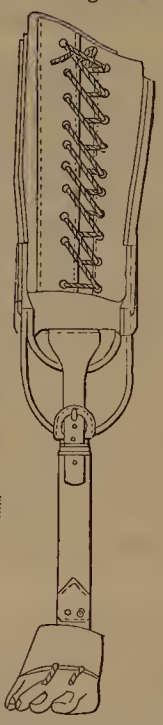
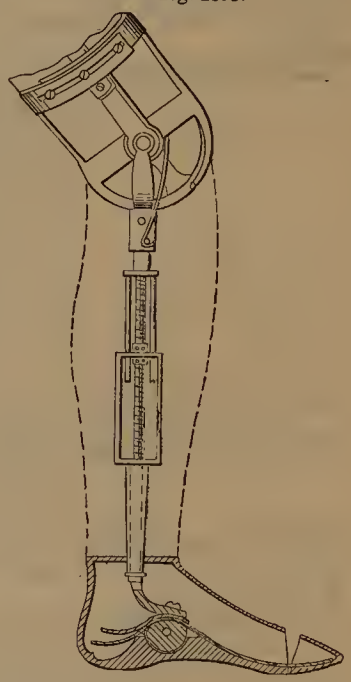


Fig. 2895.

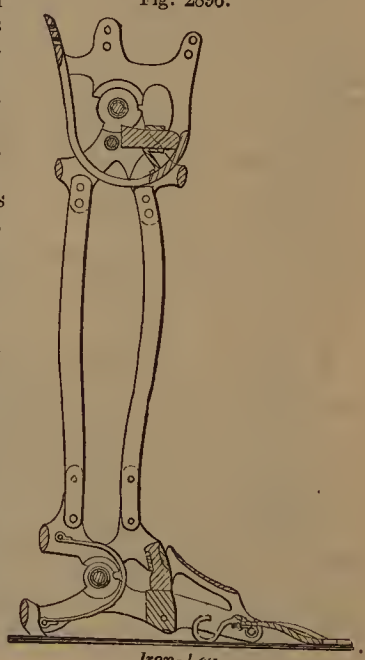


Artificial Legs.

cushioned socket, or it may answer for the less common amputation at the knee-joint, the axis of movement being above the knee-rest and in prolongation of the axis of motion of the knee. *b b* are branches of the thigh-straps; depending from the knee-joint are branches which connect with and brace the tibia post.

Fig. 2895 is a leg adapted for thigh amputations. The bar of the leg is adjustable in length, and is planted upon a segment of a cylinder, which has a backward and forward oscillation in its socket; the toe and heel leaf-springs modify and limit its vibrations. The toe-spring extends the toe-section, which is hinged to the front part of the foot, and flexed by the act of walking. The slotted hoops and set-screws of the thigh adjust its capacity. An axial coil on the knee-articulation extends the leg for forward movement when raised from the ground.

Fig. 2896.

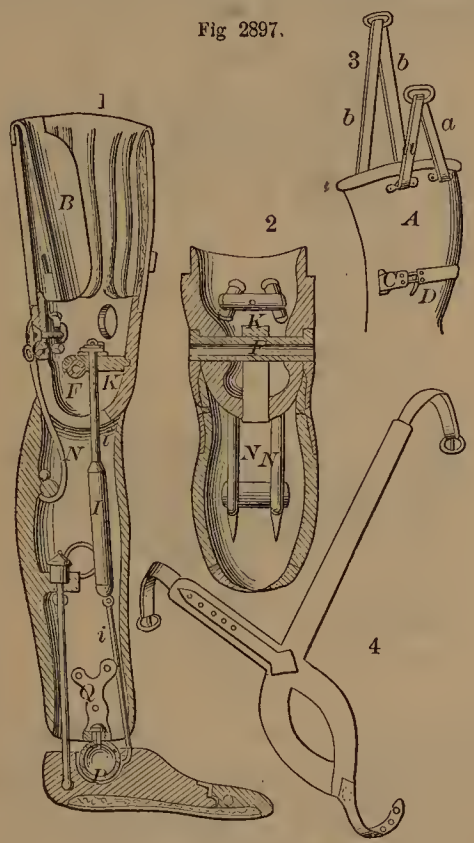


Iron-Leg.

In Fig. 2896, the frame is made of malleable cast-iron, with projections to correspond with the natural processes. Straps unite the anterior and posterior portions of the knee-frame and keep the covering in place. The toes are of spring metal, and attached separately to the foot; a spring at the ankle articulation depresses the heel.

Fig. 2897 is an artificial leg for thigh amputations. The socket *A* has a pad *B* and strap *D* for adjusting the size to the stump. *K*, in 1 and 2, is a bridge-piece in the upper section, resting on the knee-bolt *F*, and affording the superior point of attachment for the extensor-spring *I* and tendons *i i*, which throw the foot upward and forward as soon as it is lifted from the ground in walking. The ham-

Fig 2897.



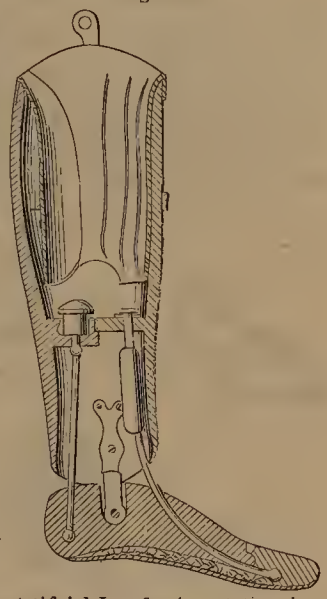
Artificial Leg for Thigh Amputations.

strings *N N* are attached to the posterior portions of the thigh and leg, to act as checks to the forward motion of the leg.

The ankle-joint consists of a socket in the foot, and a ball *P* attached by its neck and the iron frame *Q* to the leg, and has a horizontal stud upon it, fitting its appropriate recess in the socket in the foot, so as to prevent vibration in a horizontal plane, while leaving the joint free for motion in vertical planes, as described. The elastic straps *a b* (3) are proportioned as to length and strength, and afford a means of attaching the suspensory yoke (4), whose straps pass over the shoulders, so as not alone to bring the weight upon the framework of the body, but also to enable the shoulders, by their motion, to influence the action of the artificial limb. See patents of Bly, Condell, and others.

Fig. 2898 is an artificial limb intended for amputations below the knee, and is supported by straps secured to the sides of the socket, and an elastic band secured to the front of the socket, the said straps and band uniting in a stronger elastic strap which passes upward, and is suspended from a yoke-strap over the shoulder. The foot-piece has a socketed axial-bolt passing transversely through its rear portion, which is secured to a bar projecting up into the leg, and forms the ankle-joint.

Fig 2898.



Artificial Leg for Amputations below the Knee.

Le'gend. An inscription or motto in heraldry or on a coin.

Leg'gings. Wrappers used in connection with shoes or bootees, to form a protection for the legs in hunting, riding, or in rough and exposed work. They are very common among the agricultural part of the population of England, and in some parts of the continent they seem to be considered a necessary part of the hunting-costume. They are made of pliable, unblacked leather, dressed like buckskin, and are buttoned down the outer edges.

When used to protect the pantaloons or boots of an equestrian, they are sometimes called spatter-dashes. One form has pliable springs in the upper edge and just above the ankle. The legging is sprung open to admit the foot, and the springs then close the legging around the leg.

The Romans had leather spatterdashes, buttoned at the sides, and probably introduced them into England. They were common among the Anglo-Saxons.

Leg and Foot Guard. (*Menage.*) A device to protect a horse's feet or legs.

They are of several kinds.

1. To prevent the cutting of the fetlock or foot by *interfering* or *overreaching;* that is, by striking the fore or hind foot against its fellow as they pass each other in motion, or striking the heel or shoe of the front foot by the toe of the hind foot or shoe.

2. To prevent the cutting of the knees in kneeling or falling forward on to the knees.

3. To prevent the unhairing or abrasion of the hide by hopples. See Hopple.

Rotch's flexible elastic horseshoe, patented in England in 1810, and with improvements in 1830, consisted of a sheet-metal sole and a body of india-rubber made to fit over the crown and upon the pastern. The immediate purpose of the caoutchouc cover was to hold on the sole to which a regular bar-shoe was riveted, if necessary. The india-rubber covering, in the case of *interfering* horses, was prolonged over the fetlock in order to keep the hide from abrasion by the blows of the other foot, or from being barked or cut by the toe of a hind foot in horses addicted to *overreaching*.

Fig. 2899 shows several kinds.

a has a protecting pad, which catches in the crevice between the heel and the shoe, and is fastened by a hook engaging with the clip in front.

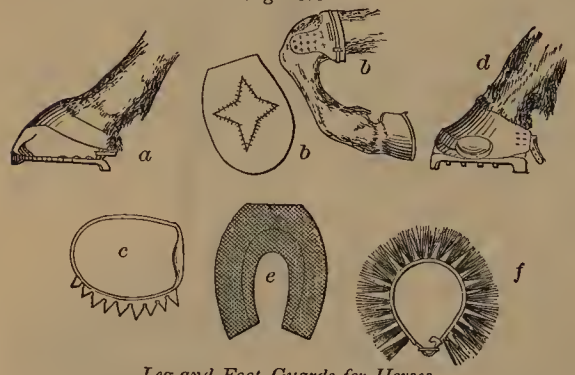
b has a pad or fender to fit the inside of the knee-joint and ankle-joint of a horse addicted to interfering; it has also an interlining or stiffener, and a whalebone strip at the upper end of the fender to prevent the pad from turning round the leg.

In *c*, a band surrounds the hoof at its crest, with flexible projections of caoutchouc, to prevent injury from interfering.

In *d*, the spur is inserted between the shoe and the hoof, and holds in position the inflated pad on the strap, which is secured around the hoof.

In *e*, the upper surface of the elastic inner shoe conforms to the shape of the hoof; the under surface

Fig. 2899.



Leg and Foot Guards for Horses.

rests on the shoe, and the peripheral flange prevents cutting by interference.

f has a strap with bristles protruding.

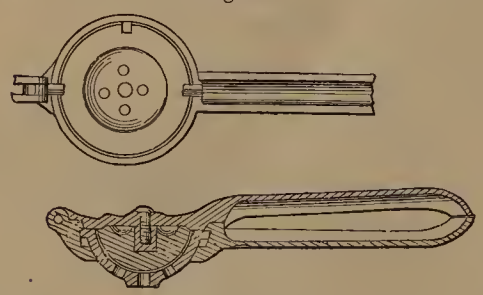
2. A lined sleeve, as a hopple-ring, to prevent abrasion of the fetlock. See HOPPLE.

3. A stout piece of leather, strengthened by a longitudinal iron plate. It is strapped to the right leg of an artillery-driver, to prevent injury from the pole of the carriage.

Leis'ter. A pronged fish-spear.

Lem'on-squeez'er. One for pressing the juice from lemons. In the example, the parts have a cup

Fig. 2900.



Lemon-Squeezer

and a bulb respectively, and are pressed together by the handles.

The making of orangeade and lemonade was introduced into England from France about 1632. These fine acids need sugar, and this is a comparatively modern ingredient in Europe. See SUGAR.

Length'en-ing-bar. An extension-piece for the leg of a drafting compass, when the reach of the ordinary legs is insufficient.

Length'en-ing-piece. (*Shipbuilding.*) One of the timbers added to the ribs above the *top-timbers*, to impart the necessary light to the sides of the vessel.

Length'en-ing-rod. A rod with a screw and screw-socket at the respective ends; attached endwise to form a long shank for an auger or drill in deep boring.

Le'no. (*Fabric.*) An open cotton goods, thinner than *buke-muslin*, used for veils, window-curtains, etc. It is plain, colored, or checked.

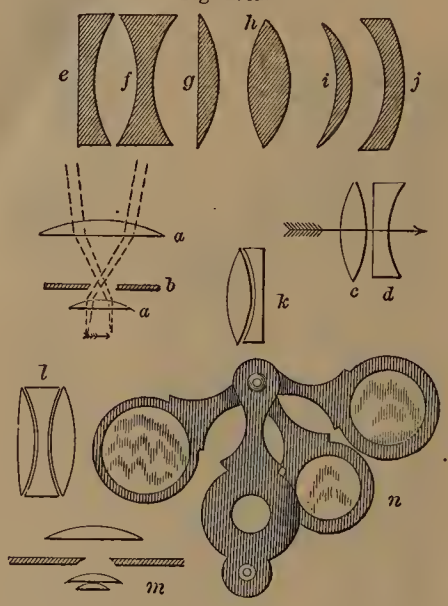
Lens. A piece of a transparent substance fashioned into a shape affording two regular opposite surfaces, both curved, or one curved and the other plane. The curved surfaces are usually spherical, and the ordinary lenses of this description are of six varieties. They are: —

e, plano-concave.	*h, double convex.*
f, double concave.	*i, meniscus.*
g, plano-convex.	*j, concavo-convex.*

A lens changes the direction of rays of light, diminishing or increasing the apparent size of objects viewed through it. Combinations of lenses increase this effect. For an explanation of the principles, see treatises on optics.

There are varieties of lenses peculiar from their

Fig. 2901.



Lenses.

proportions, their construction, arrangement, or their specific effects.

The *crossed lens* is a double convex, in which the radius of one face is six times that of the other.

The *polyzonal lens* is built up of several pieces arranged in zones or rings.

The *multiplying lens* is plano-convex, and its curved surface is covered with a number of plane faces or facets, each of which affords a separate image.

The *aplanatic lens* is a lens constructed of different media, so as to correct the unequal refrangibility of the different rays.

The *achromatic lens k* is a combination of a double convex lens of crown-glass and a plano-concave or a concavo-convex lens of flint-glass. The advantages of a lens formed in this manner are freedom from spherical aberration or distortion, and the rays of light are not decomposed into the primary colors; in other words, the light passes through the lens and suffers no change thereby. They were formerly combinations of three lenses, as shown at *l*. They were made by Dollond in 1753. See ACHROMATIC LENS.

The *Coddington lens* is of spherical form, and has a deep equatorial groove around it filled with opaque matter, acting as a diaphragm to diminish the quantity of light and exclude lateral rays.

A spherical silica lens is ascribed to an experiment of Sir Humphry Davy. One end of a wheat straw is ignited, and the spear is allowed to consume grad-

ually. The cinder is then heated in the blue flame of a burner, and from the silica obtained a solid globule of glass is formed, which is said to be well adapted to microscopic purposes.

A *cylindrical lens* has a body formed of a segment of a cylinder, or of two such segments united by their bases. A *Stanhope* lens.

A *diamond lens* is made from a diamond whose high refractive power is supposed to render it specially suitable for an eye-glass. Diamond lenses were made by Andrew Pritchard in 1824.

A *doublet* is an arrangement of two plano-convex lenses, invented by Wollaston, as shown at *a a*; *b* is a diaphragm. *c d* is Herschel's doublet.

A *triplet m* is an arrangement of three plano-convex lenses in a microscope. Invented by Holland.

n is also a threefold arrangement of lenses, any two or all of which may be used in combination, according to the power desired.

Eye-glass; the lens nearest to the eye in a simple arrangement, and the one nearest to the eye of the glasses forming the combination *eye-piece* of a telescope or microscope.

Compound eye-glasses are *doublets* and *triplets* (which see). See NEGATIVE EYE-PIECE.

An *immersion lens* is an achromatic objective for the microscope, which is used with a drop of water between the front lens and the cover of the object examined. See IMMERSION-LENS.

Object-glass; the *field*-glass, or the one farthest from the eye, in the combination of lenses forming a telescope or microscope.

Periscopic lens; a concavo-convex lens, the ratio of the radii of whose respective faces constitutes it a magnifying or diminishing lens; the general curve of the lens approximating that of the cornea and increasing the distinctness of the image when viewed obliquely.

Polyscope; a plano-convex lens, whose curved side has facets by which the images are multiplied. A *multiplying-lens.*

Polyoptron; a plano-convex lens, whose curved face has a number of *concave* facets which afford a number of diminished images.

The *spherical lens* is of a globular shape, and has usually an equatorial groove filled with an opaque object to exclude lateral rays. A *Coddington lens.*

The *Stanhope lens* is of a cylindrical form, and has convex ends having different radii.

It is, perhaps, impossible to determine when lenses were first made. The first observations of their effects were, no doubt, with drops of dew upon leaves, and occasionally by a spawl of crystal or a tear of vitreous matter from the inside of a furnace.

Whether the means by which Archimedes burnt the fleet of Marcellus at Syracuse was a combination of mirrors or lenses, it is hard now to determine. Probably mirrors. The same may be said of the burning by Proclus of the besieging ships of Vitalian the Scythian, at Constantinople, in the sixth century.

Refraction was observed by the ancients, and Archimedes is said to have written a book upon the subject. Plutarch speaks of instruments used by Archimedes "to manifest to the eye the largeness of the sun."

The appearance of a straight stick when thrust obliquely into water seems to have led the ancient philosophers to consider the subject. They determined that a ray of light was bent in passing from one medium to another; and Ptolemy, the astronomer and physicist, says that "the light of the heavenly bodies falling upon our gross atmosphere is bent out of its rectilinear course, which causes these luminaries to appear to rise sooner than they do in reality."

Euclid's treatise on optics was about 280 B. C. He is the one who told his royal master Ptolemy Philadelphus, "There is no royal road to learning, sir."

"Ptolemy was the first to measure refractions, and is therefore the founder of an important part of optical science." — HUMBOLDT.

"The magnifying power of hollow glass spheres filled with water (Seneca, 1, 6) was, indeed, as familiar to the ancients as the action of burning glasses or crystals (Aristoph. Nub. V. 765 [424 B. C.]) and Nero's emerald (Pliny, xxvii. 5)." — HUMBOLDT'S *Cosmos.*

Layard found in the ruin called Nimroud a plano-convex lens of rock-crystal 1½ inches in diameter and $\frac{3}{10}$ of an inch thick. It shows the marks of the lapidary's wheel. It gives a focus 4½ inches from the plane side. Sir David Brewster says, "It was used as a lens, either for magnifying or for condensing the rays of the sun." Two glass bowls were found in the same chamber. Before the discovery of the lens, it had been surmised that the minute inscriptions in the cuneiform character must have been executed by the aid of a magnifying-glass.

There are other notices of lenses scattered through the pages of antiquity. Pliny mentions that the ancients had globes of glass and crystal, and that Nero used glasses when he watched the fights of the gladiators. The old scoundrel was probably troubled with myopia, and had concave glasses. This we must suppose rather than that he had a combination of lenses similar to a telescope or opera-glass. Lactanens says that a hollow glass sphere full of water will produce the effect of a solid sphere of glass. Iamblichus, in his "Life of Pythagoras," tells us that the latter strove to contrive instruments that should aid hearing as effectually as optic glasses and other contrivances aided sight.

Coming down from the time of Ptolemy to the revival of learning and science under the Saracens, we find that Alhazen, in the twelfth century, wrote on the refraction of rays and the magnifying power of lenses. Draper's remark here is too good to omit.

"I join, as, doubtless, all natural philosophers will do, in the pious prayer of Alhazen, that, 'in the day of judgment, the All-Merciful will take pity on the soul of Abu-r-Raihân, because he was the first of the race of men to construct a table of specific gravities'; and I will add Alhazen's name thereto, for he was the first to trace the curvilinear path of a ray of light through the air."

Abu-r-Raihân was a native of Byrun in the valley of the Indus, and a friend of Avicenna, who lived with him at the Arabian academy in Charezm. His history of India belongs to the years 1030–32.

Vitellio, a Pole, wrote a treatise on lenses about 1270.

The magnifying power of segments of spheres was known by the Florentine Salvino degli Armati, who died 1317.

To come down to later times, we find that spectacles were well known in the thirteenth century, and it is not known by whom they were invented. The invention has been credited to Roger Bacon (1250), and to Alexander de Spina (1280).

Roger Bacon speaks in regard to the effect of lenses as familiar, and the remarks he makes belong to the second branch of the subject, which concerns the combinations of lenses to produce the compound microscope and the telescope.

This invention consists in placing lenses of certain character at proper distances on a common axis. The character will determine the effect, and the

focal length will determine the proper distance; the common axis is imperative. Who first held two lenses in the proper relation, so as to produce an effect the result of their combination?

A few of the items in this inquisition may be noted. Roger Bacon (1250) says: —

"We can give such figures to transparent bodies, and *dispose them in such order*, with respect to the eye and the objects, that the rays shall be refracted and bent towards any place we please; so that *we shall see the object near at hand*, or at a distance, under any angle we please. And thus from an incredible distance we may read the smallest letters, and may number the particles of dust and sand by reason of the bigness of the angle under which we may see them."

The change in apparent magnitude of distant and near objects by a proper disposition of several lenses of the required character involves the invention of the telescope and compound microscope.

In a book printed in 1551, "the glasse he [Friar Bacon] *made* at Oxford" is referred to, and the venerable philosopher is defended from the assumption that its marvels were due to the infernal power; "for," said the writer, "I know the reason to be good and natural, and to be arright by geometry, and to stand as well with reason as to see your face in a glass."

This must have been the combination of lenses referred to by Bacon, as a mere lens was well known and would excite no marvel, spectacles having been well known for three centuries, and the naked lens for a time that the memory of man runneth not to the contrary.

Frascatoro, who died in 1553, states the matter properly: "If any one will look through two lenses, one placed over the other, he will see everything much larger and clearer."

J. Baptista Porta (about 1560) states: "If you know how to combine a convex and a concave glass, one of each sort, you will see, far or near, objects larger and clearer." He is believed to have invented the camera-obscura about this time.

Dr. Dee says (1570) that "perspective glasses" will enable a commander to ascertain the strength of an enemy's forces; referring apparently to an optical instrument then in use.

Leonard Digges (about 1571) appears to have been able, "by proportional glasses duly situate," to discover things afar off, read letters and inscriptions on coins at a distance, and tell what was passing seven miles off. Such is the claim in his son's book, second edition, published in 1591.

Jansen (about 1608), a spectacle-maker of Middleburg, Holland, was struck by the effect of a concave and a convex lens held in the proper relation and distance. For the purpose of observation, he fixed the glasses on a board in proper position, and afterwards in a tube. He seems to have considered it interesting but not valuable, and Prince Maurice of Nassau became possessed of it.

Lippersheim, also of Middleburg, seems to have been concerned in it in some way.

Another claimant of the invention about the same date is Metius, who was a glass-cutter, and casually observed the effect of a concave and convex lens held in line in the hands. The three latter claimants had their supporters as the authors of the invention.

Descartes, who lived near the time, supported the claims of Metius. Borelli, about 1650, examined the question, and decided in favor of Jansen and Lippersheim. Porta is said to have hastened his death, which happened in 1615, by the fatigue and anxiety incurred in supporting his claims.

Galileo had a hint of the invention, studied it out, and made a telescope which he soon put to use. See TELESCOPE.

Kepler (1571 – 1630) was, perhaps, the first to state with precision the effects of lenses in making the pencils of light converge or diverge. He showed that a plano-convex lens makes rays that were parallel to its axis to meet at the distance of the diameter of the sphere of convexity; but that if both the sides of the lens be equally convex, the rays will have their focus at the distance of the radius of the circle corresponding to that degree of convexity.

Cavallieri laid down the rules in regard to lenses whose sides are unequally convex. As the sum of both the diameters is to one of them, so is the other to the distance of the focus. The rule for convex glasses is applicable to concave, with the difference that the focus is on the contrary side of the glass.

Kepler, in his "Catoptrics," explains the rationale of the system of lenses in a telescope. Scheiner constructed one on this principle in 1630. His description is as follows: "If you insert two similar lenses (that is, both convex) in a tube, and place your eye at a convenient distance, you will see all terrestrial objects, inverted indeed, but magnified and very distinct, with a considerable extent of view." He afterward added two more glasses, which reversed the image and brought it to the natural position.

Rheita was the first to employ the combination of three lenses, the *terrestrial telescope*.

Snellius of Leyden, Descartes (1596 – 1650), and Leibnitz (1646 – 1716) stated the doctrine of refraction more or less fully; and Grimaldi, an Italian painter, demonstrated the ellipticity of the sun's image after refraction through a prism; Newton (1642 – 1727) determined that it was owing to the difference in the refrangibility of the respective portions of the rays.

Newton supposed that *refraction* and *dispersion* were indissolubly united, but Dollond demonstrated that by using two different kinds of glass he could abolish the color, and yet leave a residue of refraction.

Refraction has reference to the deflection of the ray, *dispersion* to the diverging of the components of the ray, incident to the different refrangibility of the parts of which it is constituted. *Dispersion* is therefore *decomposition*, while *refraction* is *bending* at an angle. The *direction* of the dispersion depends upon the form of the surface on which the ray impinges; the *extent*, upon the nature of the medium. The flat face of a vertical prism gives a strictly lateral divergence, and simply widens the image, the colors resulting from the decomposition taking up their places in parallelism, the red as the least refractive at one edge, and the violet as the most refractive at the other edge. There is also a non-visible portion of spectrum at each end; *heat* at the *red* end, *actinium* at the violet end.

The amount of *dispersion* of light, or the length of the spectrum formed by prisms having the *same refracting angle*, varies greatly in different media. Newton supposed that the *dispersion* was always proportional to the *refraction*, but Dollond ascertained that although the average *refraction* of the ray might be the same in two media, yet the *dispersion* or diverging effect might be much less in one than in the other.

Euler (1707 – 83) was the first to state that it must be possible to produce an achromatic lens by using media of different densities. Dollond, in trying by experiments to disprove this supposition,

proved its truth. He adopted flint and crown glass, which have a difference in refractive powers in favor of the latter, accompanied by a still greater difference in dispersive powers in favor of the former. He took two lenses, one concave and the other convex, — which are, in effect, equal to two prisms refracting in different ways, — so arranged that the *dispersive* powers of the flint-glass would be corrected by the crown-glass, and the image produced by the excess of refraction of the latter would be sufficiently colorless for the purpose.

The difficulties incident to procuring lenses of homogeneous quality, large size, and free from striæ, have been very great, and deserve a passing notice. Sir Isaac Newton declared them insurmountable, and the English, French, and Germans of the last century labored hard at the problem. The Academy of Sciences at Paris offered prizes, and subsequently a commission consisting of Herschel, Faraday, Dollond, and Roget were instructed to pursue the inquiry. The excise system of England at that time sat like a foul bird upon all the nests where glass was hatched, and prevented the experiments, tying the hands of this noble quarternion of philosophers with a few yards of red tape applied by some seedy-looking individual, with a pen behind his ear and no speculation in his eye.

Munich at last carried the palm; her skill being originally derived from Guinand, a poor peasant of Neufchatel, Switzerland, who was brought up to the watch-trade. He made experiments, and gradually shifted himself into the manufacture of optical instruments, finally allying himself with Utzschneider and Frauenhofer of Munich, whose establishment yet has a world-wide reputation: he succeeded in soldering glass. Pure disks of flint-glass were exhibited in London in 1851, having a diameter of 29 inches and weighing 224 pounds.

Guinand's mode of making lenses is stated by Mr. Pellatt to have consisted in stirring the glass while at the highest point of fusion; cooling down the entire contents of the pot in a mass, and when annealed and cooled, separating unstriated portions by cleavage, afterwards softening the piece in clay molds which gave the shape. The plan has been pursued by his successors.

A powerful lens was made some years since by Parker of London. It was of flint-glass, 3 feet in diameter; $3\frac{1}{4}$ inches thick at the center; focal distance, 6 feet 8 inches; diameter of the burning focus, 1 inch; weight, 212 pounds. The rays refracted by this lens were received on another, the diameter of which in the frame was 13 inches, and its focal length 29 inches. This reduced the diameter of the burning focus to $\frac{1}{2}$ inch, quadrupling its power. It cost $3,500, and melted: —

Pure gold	20	grains in	4	seconds.
Silver	20	"	3	"
Copper	33	"	20	"
Platinum	10	"	3	"
Cast-iron (a cube)	10	"	3	"
Steel	10	"	12	"
Common slate	10	"	2	"
A topaz	3	"	45	"
An emerald	2	"	25	"
Crystal	7	"	6	"
Lava	10	"	7	"
Flint	10	"	30	"
Jasper	10	"	25	"
Carnelian	10	"	75	"
Pumice-stone	10	"	24	"

Wood burned immediately; water flashed into steam; bones fell into a calcined form at once.

This glass was carried to China by Lord Macartney, and was left in Pekin. It was probably stolen or destroyed in the sacking of the summer palace by the allies.

A flint-glass lens, weighing 224 pounds, was exhibited at the London Exposition, 1851.

A burning-lens of great power may be obtained by fixing two circular disks of thin glass at the opposite ends of a tube, say 1 inch long, and injecting into the space between them, under pressure, turpentine, bleached oil, or other liquid of high refractive power. When the glass attains the required curvature, close the stop-cock and mount the fluid-lens for use.

The lens of the new Naval Observatory at Washington has been made by Alvan Clarke & Sons, of Cambridgeport, Mass. It is 26 inches in diameter; the telescope is now in working position in the building erected for it under the superintendence of Professor Newcomb.

See the following varieties: —

Achromatic lens.
Aplanatic lens.
Bull's-eye.
Coddington lens.
Concavo-convex lens
Condensing-lens.
Convex lens.
Convexo-concave lens.
Convexo-convex lens.
Crossed lens.
Cylindrical lens.
Diacaustic lens.
Diamond-lens.
Double-concave lens.
Double-convex lens.
Doublet.
Eye-glass.
Eye-lens.
Field-lens.
Fluid-lens.
Immersion-lens.
Lenticula.
Lunette.
Meniscus.
Microscopic lens.
Multiplying-lens.
Object-glass.
Orthoscopic lens.
Pebble.
Periscopic lens.
Photographic lens.
Plano-concave lens.
Plano-convex lens.
Polyoptron.
Polyscope.
Polyzonal lens.
Spectacle-lens.
Spherical lens.
Sphereometer.
Spot-lens.
Stanhope lens.
Stereoscopic lens
Telescopic lens.
Triplet.
Varnish-lens.

(*Lens Grinding.*) Lenses are so ground that their faces shall form a portion of a spherical surface. The tools employed are, first, a concave shell of cast-iron (*a*, Fig. 2902). This is cast from a wooden pattern of the true curvature of the lens, formed by means of a templet having a radius equal to that of the required curve, and by it, with the aid of coarse emery, the lens is ground approximately to the true form. Two templets, one convex and the other concave, are made of sheet-brass or copper, or, for large-sized lenses, of crown-glass. These serve as guides for turning the convex and concave tools *b c* to a proper sphericity.

The piece of glass of which the lens is formed is clipped around the edges to bring it to a circular form by means of flat pliers of soft iron, which does not slip from the glass as steel would, leaving it of somewhat greater diameter than the finished lens, and is then attached, by means of cement, to a concave, circular holdfast, somewhat smaller than the

Fig 2902.

Lens-Grinder.

lens. The concave tool *a* is now used for bringing the glass to a spherical surface. For this purpose emery is employed, coarser at first and then finer, as the face of the lens begins to assume its true form. The tool *a* is turned both circularly and transversely of the lens, so as to bring the two surfaces in contact in every possible position in order to insure perfect sphericity. From time to time the concave tool *b* is ground in a similar way upon the convex tool *c*, in order to preserve the correctness of its surface.

The lens is polished in one of the iron shells *a*, the interior of which is coated with cement, over which a piece of cloth is placed and pressed into shape by the convex tool. This is covered with putty powder (peroxide of tin). The manipulations are similar to those just described. Finally, the edges of the lens are ground to their true diameter.

d is a convex tool or *runner* of cast-iron, of about ½ inch less radius than the templet, used as a support for common glasses, a number of which are ground together.

Another contrivance for polishing lenses and other bodies of spherical form consists of a cup connected by a ball-and-socket joint and a bent arm, with a rotating upright shaft set concentric to the body to be polished. The cup, being set eccentrically on the joint, has an independent rotation at the same time that it revolves around the common axis. This prevents any part of the surface of the cup from coming repeatedly in contact with the same parts of the body which is being ground or polished.

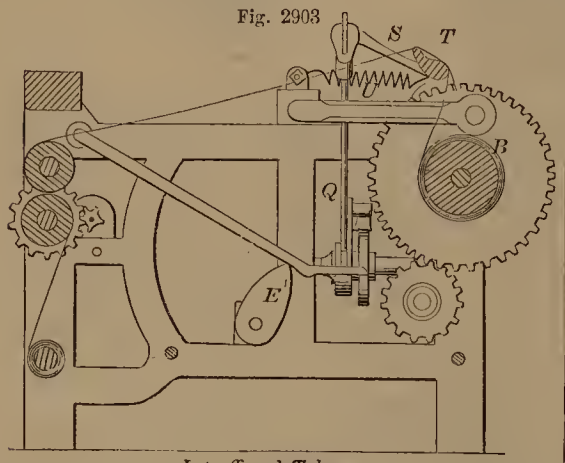
Len-tic'u-la. A small lens.

Le-pine'-watch. A flat form of watch, invented by Lepine of Paris.

The wheels are held by bars, technically called *cocks*, instead of being pivoted in two parallel circular plates.

Let-off. (*Weaving.*) An arrangement in a loom by which the yarn is paid off from the beam at such a rate as it shall be required by the weaving-process, and which is dependent upon the rate of the *picks*,

Fig. 2903



Let-off and Take-up.

the sizes of the warp and weft thread, the compactness with which it is beaten up by the lay. The *take-up* is the winding on to the *cloth-beam* of the completed web, and proceeds coincidently with the *let-off* from the *yarn-beam*. Regularity of *let-off* is secured by making the rate of surface motion of the *yarn-beam* depend upon the tension of the yarn; and the rate of revolution of the beam, to secure equal speed of let-off, will become rapid as the bulk of yarn diminishes upon the roller. The devices for this purpose are numerous. In the example, the same cam *E'* operates both the *take-up* and *let-off* devices; the strain of the yarn on the *whip-roll T* operates through the arm *S* and rod *Q*, pawls which act upon the ratchet by which the yarn-beam *B* is rotated.

Let'ter. (*Printing.*) A character used in printing. Type either of metal or wood. Used collectively to represent type, as "a case of letter," "a font of letter."

Fat letter; a type with body and face broad in proportion to its hight.

Lean letter; type thin or narrow in proportion to its hight.

Body letter; that type in which the main portion of a book or paper is printed. It consists generally of a font of type containing Roman CAPITALS (caps.), SMALL CAPITALS (small caps.), small letters (lower case), with a proper proportion of *ITALIC CAPS.* and *italic lower-case* letters. Technical works require numerous sorts in addition to the above. See FONT.

Body letter is distinguishable by the size of the type, those in most common use being —

Pearl.
Agate.
Nonpareil.
Minion.
Brevier.
Bourgeois.
Long Primer.
Small Pica.
Pica.

Half-minion, *half-brevier*, and *diamond*, sizes smaller than *pearl*, are used in notes of reference, side-notes, etc., but rarely for body letter. *English*, *Columbian*, *great primer*, and *paragon*, larger than *pica*, are used in circulars, display, and some legal works. Sizes larger than these are multiples of a smaller body (generally pica, known as 2-line pica, 3-line pica, etc.), and are used in printing posters. The body of letters differs with various type-founders. Nonpareil is generally about one twelfth of an inch; i. e. twelve lines of nonpareil measure one inch down the column. Pica is double nonpareil; 12-line pica type, therefore, measures about two inches in hight.

Letter is characterized by various names, according to the face. Besides *roman* and *italic* body type, which may be *old-style*, *new-style*, *Scotch-face*, *light-face*, *hair-line*, etc., job printers use a great variety of letter in the varied styles of printing. *Gothic*, *antique*, *Runic*, *Celtic*, *black*, *German text*, *Old English*, *script*, *title*, and scores of others might be enumerated. Nearly all of these, besides being cast to all the sizes before mentioned, are made *extra condensed* (very lean), *condensed*, *standard*, and *expanded* (fat).

Type-founders, to supply all the orders they are likely to receive, are compelled to keep on hand several thousand varieties of letter, or the matrixes for casting them.

Ascending and *descending* letters extend respectively above and below the general level of the line. b d l are examples of the former, p q y of the latter.

Kerned letter. Where some portion of the face overhangs the body, as the dot of an f. Nearly all the long letters in italic and script fonts are kerned.

Accented letter (see FONT).

Let'ter-bal'ance. A device to weigh letters for mailing. See LETTER-SCALE.

Let'ter-board. (*Printing.*) A board on which pages or columns of type are temporarily placed.

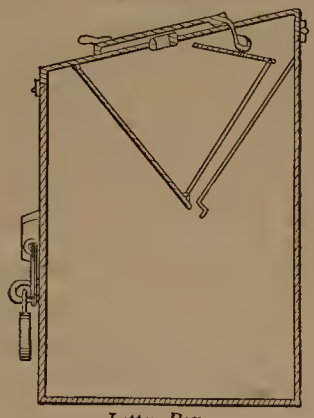
Let'ter-box. One to receive letters.

1. A locked box attached to a post in the public street, for convenience of mailing, the letters being gathered from time to time by carriers.

The box (Fig. 2904) is for attachment to a lamp-post. The letter-passage in the top has a cover whose cam-projection operates a lever inside, and the lever is connected to the free edge of the hinged plate, so as to close the aperture between the plates when the lid is raised. When the lid is closed, the letter slides off the plates through the aperture.

2. A box attached inside a door to catch the letters and cards left by carriers or callers. The

Fig. 2904.



Letter-Box.

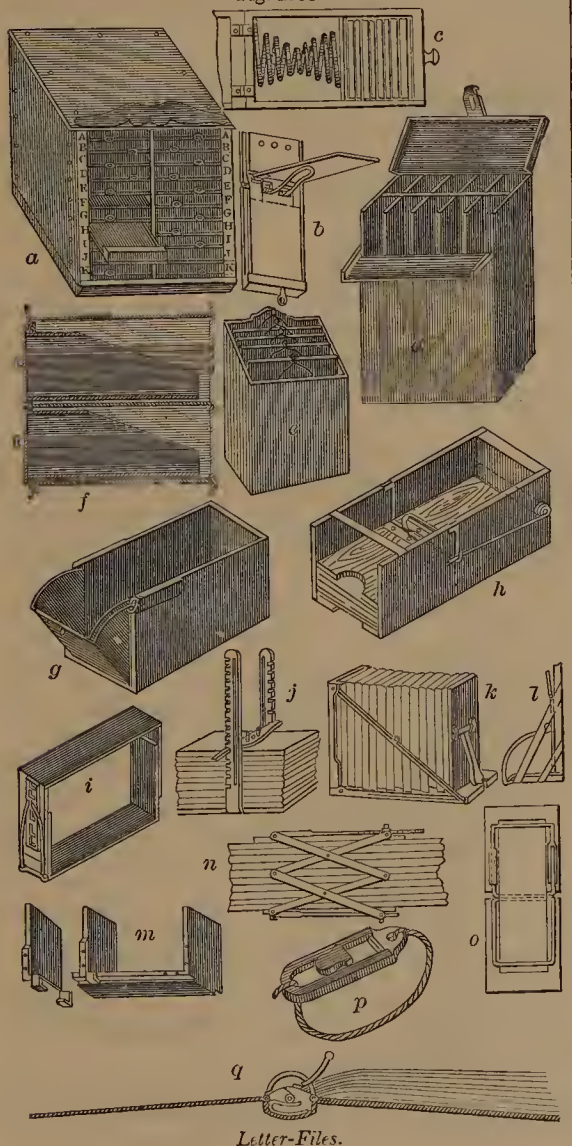
Fig. 2905.

Office-Door Letter-Box.

door-plate has provision for a slip containing the name of the occupant, and has a flap covering a chute leading to a letter-box, whose serrated plate prevents the surreptitious abstraction of letters from the outside.

3. An office-box to hold letters accumulating during the day, awaiting mail-time.

Fig. 2906.



Letter-Files.

Let'ter-case. 1. (*Printing.*) A partitioned tray in which assorted letters are placed. A *case.*

2. A portfolio.

Let'ter-clip. A spring-clasp to hold letters or other memoranda together.

Let'ter-file. A box, case, folio, or envelope, for containing letters to which reference is required to be made.

a is case with labeled drawers.

b is one of the drawers belonging to *a*, having a spring flap to hold down the letters.

c is a drawer with a spring to compact the letters against the end.

d is a box with labeled divisions and falling flap and lid.

e has pockets with lifters.

f has trays which slide into cases.

g is a tray with a let-down front.

h is a tray with a spring follower to keep down the letters compactly.

i has two three-sided pieces, which are drawn together by springs to embrace the papers.

j has racks with notches which hold the cross-bar upon the follower-board above the pile of letters.

k has a tray with a back, and a brace which locks against the pressure-board.

l shows a pressure-board held against the papers by a spring.

m has a shifting-board which may be rigid in any position. On the left, the shifting-board is shown separately.

n has a lazy-tongs arrangement to connect the two boards.

o has a spring wire-clamp.

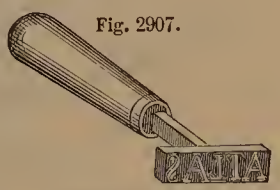
p has a cord and locking-plate.

q has flaps like a portfolio, and a binding-clamp at the back.

Let'ter-ing-box. (*Bookbinding, etc.*) A case to hold a set of movable type when composed to form a name or address, for lettering books, marking linen, etc.

Let'ter-ing-tool. A bookbinder's tool for stamping the gilt titles on the backs of books. For titles in common use, as "Atlas," "Holy Bible," etc., the whole word or words are cut on the face of the tool. In other cases movable type of various sizes are provided, which are adjusted in a slot fitted to receive them.

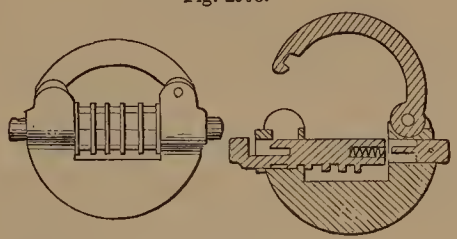
Fig. 2907.



Lettering-Tool.

Let'ter-lock. A lock whose bolt is surrounded by several rings having notches through which a set of studs on the bolt must pass before the lock can be opened. These notches are so arranged as to

Fig. 2908.



Letter-Lock.

prevent the passage of the bolt except when certain letters on a series of exterior rings are brought into line with each other so as to form a particular word or combination on which the lock has been set.

It is mentioned in Beaumont and Fletcher's play of "The Noble Gentleman," 1615.

"A cap-case for your linen and your plate,
With a strange lock that opens with A. M. E. N."

Regnier, about the middle of the seventeenth century, made improvements in the letter-lock, and is generally credited with its invention, though this has been contested. His lock is thus described: "Broad steel rings, four, five, or eight deep, upon each of which the alphabet was engraved, turned upon a cylinder of steel, and the lock only separated when the letters forming a particular word were in a straight line with one another. This word was selected from among a thousand, and the choice was the secret of the purchaser. Any one not knowing the word might turn the ring round for years without finding the right one."

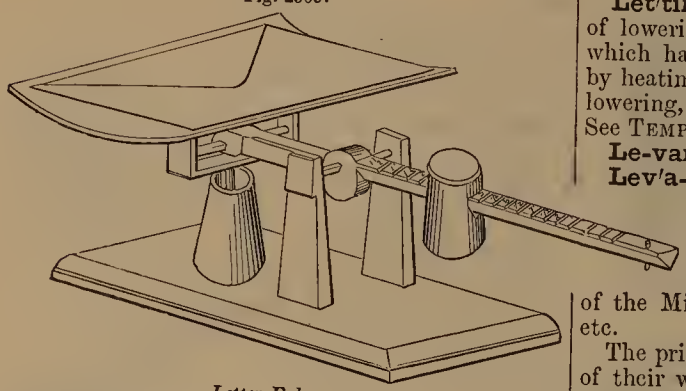
Let'ter-pa'per. (*Paper.*) Paper of post or note size, for epistolary use. The ordinary size of post is 10 × 16 inches when *flat*, and 8 × 10 when folded. Note-paper is smaller, and varies in size much.

Let'ter-press Print'ing. The ordinary form of printing in which the salient device is inked and the ink transferred to a sheet which is pressed thereupon. See PRINTING.

Let'ter-punch. A steel punch having a letter engraved on its end. Such are used to make matrixes for type; also to mark other articles of metal by giving an impression thereon when struck by a hammer.

Let'ter-scale. A balance for weighing letters and papers for mailing. That shown has a graduated beam with figures upon its flat, upper side.

Fig. 2909.



Letter-Balance.

Other forms are suspensory, having spiral springs, or rest upon a stem supported by a spring.

Let'ter-stamp. A form of stamp for defacing postage-stamps; or for attaching the place of mailing, destination, notices for carrier, deficient postage, "too late," "forward," and what not.

The United States Post-Office Department uses a hand-stamp for postmarking letters and canceling or defacing their postage-stamps. The tool consists of two small cylinders about an inch apart, fastened to a wooden handle. One cylinder bears type for the postmark, which may be removed and changed. The other cylinder carries a cork, its face generally cut in the form of a star, cross, or some fanciful device. This cork is struck upon the postage-stamp by the same blow which imprints the postmark upon the envelope. The stamp is inked by a dab upon a piece of printers' roller-composition. Letters to be postmarked are spread out upon a table covered with leather or rubber, and are postmarked and their stamps canceled as fast as blows can be struck with the postmarking and canceling stamp, or, when the latter is in the hands of an expert, nearly as fast as a person can count.

Stamps bearing such legends as "3 due," "missent," "forward to writer," etc., are small sticks of boxwood, about 4½ inches long and 1 inch in diameter, turned to a handle at one end, and the words engraved on the other. They are struck upon the letters in the same way as the postmarking and canceling stamps. Metallic stamps were formerly used for this purpose, but they have been nearly or quite superseded by those of wood.

In the General Post-Office, London, 140 stamp-canceling machines are employed. The object is to deface the stamp on letters, and impress the date, which can be done with one machine at the rate of 200 letters per minute. It consists of an apparatus in which the letters are ranged in rows, and has a double joint, so that it can run to and fro with a range of about a yard. The dies, of which there are two, — one for effacing the postage-stamp, and one for impressing the date, — are fixed to one frame, and are inked by the same roller, which is always kept in contact with a long porous pad, curved, to coincide with the path of the roller, as it runs down to pass over the dies, or up out of their way. The ink-reservoir lies on the pad, which is kept saturated. One blow from the hand of the operator impresses both stamps. Four stout wires around the effacing-die project a little beyond it, so that in stamping letters with bulky inclosures, the portion of the envelope to be stamped may be pressed flat before it is brought into contact with the die.

Let'ting-down. (*Metal-working.*) The process of lowering the temper of a steel tool or spring, which has been made flint hard and then reduced by heating to the degree of hardness required. In lowering, the temper is known by the color reached. See TEMPERING.

Le-vant'ine. (*Fabric.*) A kind of silk cloth.

Lev'a-tor. (*Surgical.*) A lever for raising a depressed portion of the skull. It belongs to the trephine case.

Lev'ee. An embankment to restrain water, and of a magnitude such as those of the Mississippi, Ganges, Holland, Po, Thames, etc.

The principal rivers noted for the periodical rising of their waters are the Nile, the Ganges, the Euphrates, and the Mississippi. Of these, the Nile, which flows from the mountains and lakes of Central Africa, begins to rise in June, and by the middle of August attains an elevation of 24 to 28 feet in the upper country, and less towards the mouth, the inundation flooding the cultivatable valley of Egypt. The Egyptian embankments are described by Herodotus and Strabo. The Ganges, flowing from the Himalayas, rises 32 feet from April to August, and creates a flood of 100 miles in width. The Euphrates, from Mount Ararat, rises 12 feet between March and June, and covers the Babylonian plains. The Mississippi rises with the melting of the snows, its various tributaries, the Missouri, Ohio, Arkansas, and Red rivers, turning in their supplies from the elevated interior regions. At a distance from the ocean its rise is 50 feet, while nearer the sea its rise is considerably reduced by the vast tract which it covers.

The Mississippi was discovered by De Soto, 1542, and explored at its upper end by Father Marquette and M. Joliet about 1672. M. La Salle traversed its whole length in 1677, and De Iberville was the first to enter it from the sea.

The dikes of Holland are marvelous, and are referred to under DIKE, DRAINING (which see). The Haarlem Lake is one of the latest recoveries from the

sea. It was 15 miles long and 7 broad, and was drained by embanking and pumping, the work being completed in 1852. Three steam-engines were employed for several years. (See PUMPING-ENGINE; also pages 116, 739.) It is now proposed to inclose and pump out the Znyder Zee, a part of which was once habitable but was overwhelmed by a storm which tore down the dikes.

It has been calculated that nearly nine hundred thousand acres have been gained in the Netherlands by diking and draining. The province of Zealand consists of islands washed by the sea on their western coasts, and separated by the many channels through which the Schelde and some other rivers find their way to the ocean. In the twelfth century, these islands were much smaller and more numerous than at present. They have been gradually enlarged, and, in several instances, at last connected by the extension of their system of dikes. Walcheren is formed of ten islets united into one. At the middle of the fifteenth century, Gœree and Overflakkee consisted of separate islands, containing altogether about ten thousand acres. By means of above sixty successive advances of the dikes, they have been brought to compose a single island, whose area is not less than sixty thousand acres. The first dikes of Holland are attributed to the Romans.

A levee 6,000 yards in length defends the Romney Marsh, Essex, England, from overflow by the sea. The levee was made during the occupancy of Britain by the Romans, and is kept in good order, 24,000 acres of rich land being thus obtained. The fresh water in the ditches passes off at the lowest state of the tide by three sluices.

In Lincolnshire, England, 400,000 acres of fever-and-ague breeding swamp-land have been transformed into fields of wheat, barley, and oats, and excellent meadows. See SCOOP-WHEEL.

Lev'el. An instrument for indicating a horizontal line, or determining the position as to horizontality of an object or surface to which it is applied. See also CONTACT-LEVEL.

The Roman instruments for leveling were the *libra aquaria* and the dioptera of Hipparchus, the father of astronomical geography. The name is derived from *libella*, Lat. a balance, from the similarity in form, the long arm and perpendicular post. The word *libro* meant to level or to weigh.

The *libra aquaria*, we may deduce from Vitruvius, to have been a tube with upturned ends and holding water. It was probably mounted on an axis so as to be oscillated like a balance (*libra*), to adjust it on a vertical plane. Vitruvius remarks that Archimedes had stated that a surface of water was not level, as it partook of the convexity of the earth, yet, he observes, the water will rise in the ends of the tube to an equal hight if the instrument be held level.

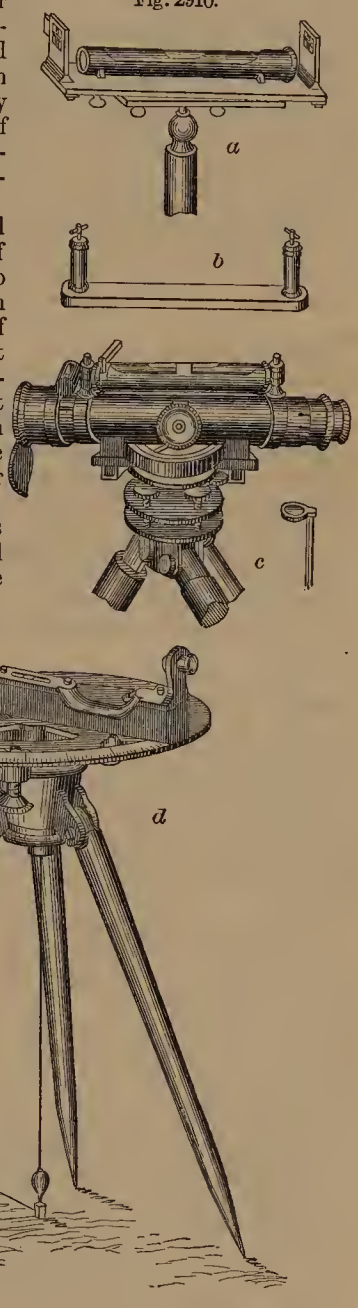
"The surface of water is not flat, but, on the contrary, convex, of a spherical shape. On this account, one who is on the sea, with a lighthouse in the distance, first descries its summit, and afterwards makes out to discover, little by little, what is below the summit, all of which was before, as a matter of course, concealed; for, excepting the convexity of the earth, there is nothing to hide every other part but the summit, in the case supposed." — AL KHÂZINÎ (twelfth century) in "The Book of the Balance of Wisdom."

Al Khâzinî was at the court of, and dedicated this work to the Saljûke Sultan Sanjar, who reigned over a large part of the Khalifate of Bagdád, 1117–57. It is not clear that he was identical with Alhazen, the Iberian Saracen. (See pages 141, 212, 1154.)

Another Roman level was the *chorobates*, which was a light wooden frame about 20 feet in length, and mounted on a leg at each of its extremities. The longitudinal piece and the end pieces were braced by diagonals marked with vertical lines. A plumb-line suspended at each extremity swung over a diagonal, and indicated, by reference to the line, the horizontality of the instrument. It was much like the modern level.

When the wind disturbed the quietude of the plumb-line, a channel in the upper edge of the horizontal bar was filled with water. When the water equally touched each end of the channel, the instrument was considered level.

Fig. 2910.



Levels.

Mariotte's level has a long surface of water made so as to reflect to the eye an inverted image of the object, the point where the two objects appear to meet being on a level with the place where the surface of the water is found.

Cassini's level has a steel mirror placed a little before the object-glass of a telescope, suspended perpendicularly. The mirror makes an angle of 45° with the telescope, when the latter is brought to the horizontal or level line.

The spirit-level, used by carpenters and builders, is an instrument consisting of a straight bar with a slightly curved glass tube containing alcohol. The tangent of the tube

is the straight-edge of the instrument. For surveyors, the instrument is mounted on a stand and tripod and provided with sights, for use in leveling. One form is shown in the illustration (*a*, Fig. 2910). The spirit-tube is inclosed in a brass case and mounted on a stand, whose end plates are pierced for sights. Screws beneath the bed-plate permit accurate adjustment. Invented by Thevénot.

A description of his instrument, accompanied with figures, was first published in the "Journal des Savants," Paris, November 15, 1666, under this title: "*Machine nouvelle pour la conduite des eaux, pour les bâtiments, pour la navigation, et pour la plupart des autres arts.*" The instrument is there called an air-level; and is described as a glass tube, hermetically sealed at both ends, containing spirits of wine, which do not freeze, and a small quantity of air forming a bubble. It is stated that the instrument is capable of giving, with much exactness, the direction of the horizon, the perpendicular to the horizon, and vertical angles; and that it is easier to make, more convenient to use, and indicates a level line more readily and accurately than any other instrument.

Parker's level (*b*) consists of a glass tube of small bore, the two ends being bent at right angles and closed. The ends are about three inches high, and marked at a certain level; the tube is charged with quicksilver, so as to stand at the marked point in the tube-ends. Floats resting on the surface of the mercury have stems which pass outside and support sights through which objects are viewed. The instrument is supported on a tripod.

Gravatt's surveyor's level (*c*) consists of a telescope provided with spirit-levels. It is furnished with screws for minute adjustment, and is mounted on a tripod.

Sibley's level (*d*) is made of cast-iron, and is a cheap form of the instrument, possessing sufficient accuracy for common uses.

At one end it is provided with a sight having a small aperture with a short tube attached. At the opposite end of the level is a ring with cross wires, so adjusted that the center of the sight aperture and the intersection of the wires are level when the bubble at the center indicates that the instrument is level.

The level stands on a circular graduated table, from the center of the under side of which is suspended a plumb in the usual manner. This plumb being adjusted over any point (as the corner of a building-lot) and the first line laid out, stakes can be set in a line drawn at any desired angle to the first line, by simply turning the level upon a central pivot, provided for that purpose, the required number of degrees as indicated on the graduated table.

Brown's level (*e*) is shaped like a pair of compasses; the cross-bar, which is marked at midlength, shuts up between the legs when closed for transportation, in which condition the instrument resembles a walking-stick. It has the usual plumb-line.

The level is used to find a line parallel to the horizon. Practically speaking, two places are on a level which are equally distant from the center of the earth, but as the line of sight is a tangent and does not follow the curvature, in an observation, the excess of the apparent over the true level will be 7.9618 inches at a station a mile distant from the point of observation. Hence, proportioning the excesses in altitude according to the square of the distances, the following table is obtained, showing the hight of the apparent above the true level for every 100 yards of distance on the one hand, and from ¼ of a mile to 14 miles on the other.

Table.

Distance in Yards.	Difference of Level in Inches.	Distance in Miles.	Difference of Level in Feet and Inches.
100	.026	¼	0.05
200	.103	½	0.2
300	.231	¾	0.45
400	.411	1	0.8
500	.643	2	2.8
600	.925	3	6.0
700	1.260	4	10.7
800	1.645	5	16.7
900	2.081	6	23.11
1,000	2.570	7	32.6
1,100	3.110	8	42.6
1,200	3.701	9	53.9
1,300	4.344	10	66.4
1,400	5.038	11	80.3
1,500	5.784	12	95.7
1,600	6.580	13	112.2
1,700	7.425	14	130.1

Hebert gives the following illustrations of the useful application of the table: —

This table is adapted to several useful purposes.

First. To find the hight of the apparent level above the true at any distance.

If the given distance is in the table, the correction of the level is found in the same line with it; thus, at the distance of 1,000 yards, the correction is 2.57, or about 2½ inches, and at the distance of 10 miles is 66 feet 4 inches. But if the exact distance is not found in the table, then multiply the square of the distance in yards by 2.57 and then divide by 1,000,000, or cut off six places on the right for decimals, the rest are inches; or multiply the square of the distance in miles by 66 feet 4 inches, and divide by 100.

Seeondly. To find the extent of the visible horizon, or how far an observer can see from any giveu hight on a horizontal plane, as at sea, suppose the eye of the observer, on the top of a ship's mast at sea, is at the hight of 130 feet above the water, he will then see about 14 miles round; or from the top of a cliff by the seaside, the hight of which is 66 feet, a person may see to the distance of nearly 10 miles on the surface of the sea. Also, when the top of a hill, or the light in a lighthouse, or such like, whose hight is 130 feet, first comes into the view of an eye on board a ship, the table shows that the distance of the ship from it is 14 miles, if the eye is at the surface of the water; but if the hight of the eye in the ship is 80 feet, then the distance will be increased by nearly 11 miles, making in all about 25 miles in distance.

Thirdly. Suppose a spring on one side of a hill and a house on an opposite hill, with a valley between them; that the spring seen from the house appears by a leveling instrument on a level with the foundation of the house, which, suppose, is a mile distant from it; then is the spring 8 inches above the true level of the house, and this distance would be barely sufficient for the water to be brought in pipes from the spring to the house, the pipes being laid all the way in the ground.

Fourthly. If the hight or distance exceed the limits of the table, then first, if the distance be given, divide it by 2, by 3, or by 4, etc., till the quotient comes within the distances on the table; then take out the hight answering to the quotient and multiply it by the square of the divisor, that is, by 4, 9, 16. etc., for the hight required. Thus, if

the top of a hill is just seen at the distance of 40 miles, then 40 divided by 4 gives 10, the answer to which in the table is $66\frac{1}{3}$ feet, which being multiplied by 16, the square of 4, gives $1,061\frac{1}{3}$ feet for the hight of the hill. But when the hight is given, divide it by one of those square numbers, 4, 9, 16, 25, etc., till the quotient comes within the limits of the table, and multiply the quotient by the square root of the divisor, that is, by 2, 3, 4, or 5, etc., for the distance sought; so when the top of the Peak of Teneriffe, said to be about 3 miles or 15,840 feet high, just comes into view at sea, divide 15,840 by 225, or the square of 15, and the quotient is 70, nearly; the answer to which in the table is by proportion nearly $10\frac{2}{7}$ miles; then multiply $10\frac{2}{7}$ by 15, $= 154\frac{2}{7}$ miles for the distance of the Peak.

In what has been stated, no regard has been paid to the effect of refraction in elevating the apparent places of objects. But as the operation of refraction, in curving the rays of light proceeding from objects near the horizon, is considerable, it can by no means be neglected when the difference between the true and apparent elevation is estimated at considerable distances. It is now ascertained that, for horizontal refractions, the radius of curvature of the curve of refraction is about 7 times the radius of the earth; in consequence of which, the distance at which an object can be seen by refraction is to the distance at which it would be seen without refraction nearly as 14 to 13, — the refraction augmenting the distance at which an object can be seen by about $\frac{1}{13}$ of itself. By reason of this refraction, too, it happens that it is necessary to diminish, by $\frac{1}{7}$ of itself, the hight of the apparent above the true level, as given in the table of reductions. Thus at 1,000 yards, the true difference of level, when the allowance is made for the effect of refraction, will be $2.570 - .367 = 2.203$ inches. At 2 miles it would be $32 - 4.5 = 27\frac{3}{7}$ inches, and so on.

A *level* tube, in order to be accurate, must be ground in the inside surface, against which the bubble plays, to a concavity, the curvature of which is determined according to its length of radius, and which again is governed by the sensitiveness or accuracy of reading required. For a common leveling-instrument, for instance, a curvature of 150 feet radius is all-sufficient, while for astronomical determinations radii of from 700 to 1,200 feet are often required. Unground tubes, although frequently used, are utterly unreliable, and even among the ground ones many are found that show in their length great inequalities of radius. This arises from the difficulty of shaping and using skillfully the metallic mandrel or core on which the glass tube receives its form, since it has to be formed empirically and by trial, no arrangement being possible by which the form of the mandrel could be otherwise tested. Very similar to the shaping of large lenses for telescope objectives, the forms must be corrected by frequent trials of the result.

The mandrel on which the tube is ground to an arc of a given radius has a strip, say 60° of its surface, which corresponds in its curve with the interior diameter of its tube and the camber or arc required; but the mandrel is so much smaller than the tube that the latter may be reciprocated upon it, both in the rotary and longitudinal directions, the motions, in fact, being a combination of the two, much as in grinding lenses, allowing for the difference due to the motion of a tube on a mandrel and a lens on its shaping-block. The tube is thus ground with flour emery, and then with polishing powder, upon a surface the exact counterpart of the shape required, the different portions of the tube being brought in succession to the said grinding-surface by the rolling, or, as it may be called, figure-of-8 motion described. The length of the grinding strip on the mandrel should bear a given relation to the length of the tube, so that not alone should the tube receive an equal action at each part of its length, but the grinding-surface itself may retain its shape unimpaired. The excess of length of the mandrel may be, say, one quarter greater than that of the tube.

The longer the radius to which a tube is ground, the lesser will be the versed sine of the arc relatively to the chord, and the longer will be the seconds division of the graduations of the tube. One second (1″) of arc is equal to $\frac{1}{206,000}$ part of the radius of the circle of which the tube is an arc. A level-tube ground to a radius of 1,000 feet will have its second (1″) graduations 0.058733+ of an inch apart, nearly $\frac{6}{100}$ of an inch. The level-trier constructed and used by Mr. Würdemann (the eminent optical and surveying instrument maker, of Washington, D. C., to whom I am indebted for the present detailed information) has second (″) graduations of 1 millimetre, and is ground to a radius of about 680 feet.

The English practice is to imbed the level-tube in plaster in a brass case, with an opening exposing the range of the bubble, in which condition it is subject to all the contractions and expansions of its envelope, a little more pressure upon any one part of the tube than on any other throwing the tube out of true, so that given lengths of different parts of the tube have a different value. Mr. Würdemann, on the contrary, suspends the tube as independently as possible, putting a band of paper around each end of the tube and clamping it in its brass holder by numerous white-pine wedges, leaving the greater length of the level free, suspended between the ends.

It appears from what has been said in the earlier portion of this article, that water was the liquid first employed in leveling, but at a distant period wine and eventually spirits came to be employed to avoid the difficulty due to freezing of the liquid. This change was also an improvement in respect of the greater mobility of the liquid. The comparative sluggishness or viscidity of a liquid is expressed in the time that a bubble of air takes to traverse a certain distance in a certain sized tube.

The result is expressed by water, 100; alcohol, 15; sulphuric ether, 5; chloroform, 3.

The English make long level-tubes apparently to avoid the difficulty arising from the expansion and contraction of the liquid, which decrease and increase, respectively, the size of the bubble. The American practice is to make short levels, and this has been rendered possible by placing a chamber at the end, into which any portion of the air of the bubble, short of the whole, may be admitted and detained, so that a bubble of an equal size may be attained when working at various temperatures. The *chambering* of the level-tube was introduced by Pistor and Martins, instrument-makers of a European reputation. The chamber is made by cementing a glass partition near one end of the tube, a small hole on the edge of the glass disk making a connection between the main portion of the tube and the chamber. By holding the tube with the hole upward, tipping it chamber upward, and then rotating the tube on its axis, any required portion of the air may be imprisoned in the chamber, to adapt the instrument to work in an atmosphere of any temperature, with a bubble of a normal size. Mr. Würdemann was the first to hermetically seal a tube containing the chamber, previous to which time it was closed by glass plates, bladder, and glue.

The most curious and delicate apparatus for leveling, in dividing and graduating instruments, and adapted for many other purposes, is the *contact-level* invented by Repsold, a celebrated instrument-maker of Hamburg. It is described on page 612, and room cannot be spared for duplicate descriptions.

2. (*Mining.*) *a.* A horizontal gallery or passage in a mine. The workings at different depths are

Fig. 2911

Mine-Levels.

said to be at the different *levels*, — the 50 or 60 fathom level, and so on.

b. An adit or drift forming a drain for water.

A level which opens to the surface at the side of a valley is called a *day-level*, and forms a means of natural drainage without pumping.

A *drowned* or *blind level* is a drainage-gallery which has the form of an inverted siphon.

A *dip-head level* is the one which proceeds from the foot of the engine-shaft right and left, and from which the *rooms* proceed.

c. A gutter for water to run in.

See under the following heads : —

Air-level.
Artillery-level.
Batter-level.
Battering plumb-rule.
Bevel plumb-rule.
Bubble.
Carpenter's level.
Contact-level.
Dumpy-level.
Foot-level.
Gunner's level.
Level (mining).
Leveling-block.
Leveling-staff.
Level-lines.
Libella.
Pendulum-level.
Plumb-level.
Plumb-rule.
Reflecting-level.
Road-level.
Self-recording level.
Slope-level.
Spirit-level.
Triangular level.
Water-level.
Y-level.

Lev'el-er. 1. A billiard-table foot having a screw adjustment for hight, in order to level the table.

Fig. 2912.

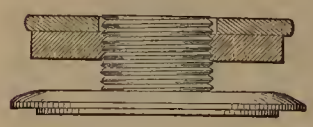


Table-Leveler.

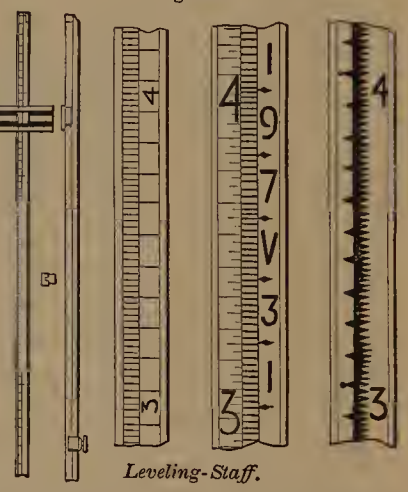
2. An earth-scraper for leveling a site.

Lev'el-ing-block. A leveling platform, consisting of large iron plates laid together and secured. The respective plates may be 8 or 10 feet long, 5 or 6 wide, and 6 inches thick. They are completely covered with holes, about 1½ inches in diameter and 4 or 5 inches apart from center to center. The mold of a given frame having been laid on the leveling-block, the figure of the molding edge is marked on it with chalk, and iron pins are stuck in the holes, so that when the iron rib is made to touch those pins it will have the proper form. In order the more easily to produce any required figure, the heads of the pins are furnished with eccentric disks or cams, by the shifting and turning of which the figure of the frame can be adjusted with great precision. Each disk has several center-holes, any one of which can be fitted on the pin.

The iron bar of the frame, having been raised to a bright orange heat in a reverberatory furnace, called a *reheating furnace*, is taken out by the smiths, laid on the *leveling-block*, and rapidly bent by means of tongs, hammers, mallets, and levers, so as to lie touching the heads of the pins.

Lev'el-ing-staff. An instrument, one form of which consists of two strips 6½ feet long, united by a longitudinal tenon and mortise so as to slide on each other and extend to a length of 12 feet. The divisions are in feet, inches, and fractions, and count from the bottom. A cross-piece or *vane* slides on the staff, and has an aperture to enable the staff graduations to be read. Inlaying with white wood gives more conspicuousness to the staff when viewed by the leveler.

Fig. 2913.



Leveling-Staff.

The staff is planted by an assistant, and the vane raised or lowered according to the signals of the engineer, until the center line of the vane coincides with the horizontal hair of the telescope. When the cross-wire of the vane is raised so high as to intersect 6 feet, it encounters a stop. If it be necessary to raise it higher, it is raised by elevating the front portion of the staff and the vane with it.

The staffs are graduated in various ways. Some have the duodecimal graduation ; others the feet divided into inches and tenths ; others the feet divided into hundredths, rejecting the inches.

Lev'el-ing-stand. (*Photography.*) An instrument used to support a glass plate in a horizontal position, so that it shall retain developing or other fluids upon its upper surface. Its usual form is a tripod, of suitable hight to stand in the developing-trough ; with three adjusting-screws by which the operation of leveling is accomplished.

Lev'el-lines. (*Shipbuilding.*) Lines representing the boundaries of sections drawn at different hights and parallel with the keel.

Water-lines are drawn parallel with the line of flotation or the true horizontal.

When the ship floats on "an even keel," the *level*-lines and *water*-lines coincide.

Le'ver. 1. (*Mechanics.*) A bar or other rigid instrument having a fixed point or a fulcrum, and

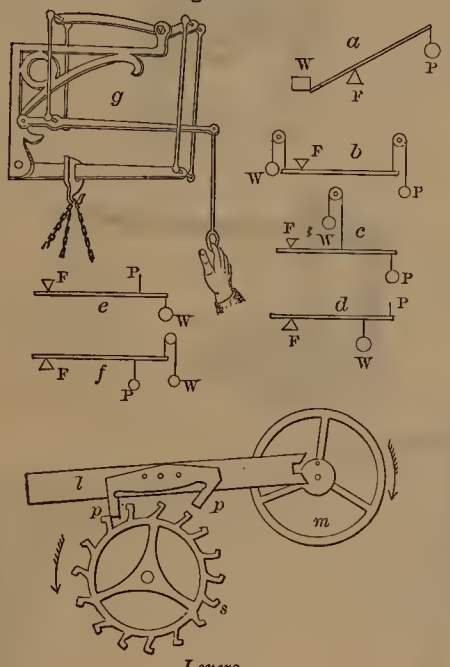
other points for the exercise of power and application to the object to be moved. There are three varieties, known as levers of the first, second, and third class, in which the fulcrum is respectively, —

1. Between the weight and the power, as at *a b*.
2. Opposite to the power, as at *e d*.
3. Opposite to the weight, as at *e f*.

g is a *eompound lever* or system of levers, the basis of the ordinary weighing-machines.

In the illustration three levers are shown. When a system of this kind is in equilibrium, of course the ratio of the power to the load will be compounded of the ratios subsisting between the arms of each lever;

Fig. 2914.



Levers.

or, in other words, the power multiplied by the continued product of the alternate arms, commencing from the power, is equal to the weight multiplied by the continued product of the alternate arms, beginning from the weight.

2. (*Horology.*) A form of escapement.

In Fig. 2914, *l* is the *lever* having *pallets p p*; *s* is the *scape*-wheel, *m* the *balanee*. The lever to which the pallets *p p* are attached turns upon a center-pin, so that the ends of the lever move backward and forward through small arcs, as the pallets are alternately released from the scape-wheel. One end of the lever has a little nick in it, which, as it passes backward and forward, catches a pin upon the balance and throws it right and left. As the lever, for example, moves to the left, one of the pallets catches a tooth of the scape-wheel, and stops the train; at the same time the balance is thrown round so that the pin passes out of the nick, and the balance swings free to the extent of the impulse; that is, it is *detaehed* from the lever. As it swings back under pressure of the hair-spring, the pin catches in the nick again, and, moving the lever back, unlocks the pallet, when instantly the other pallet is caught by another tooth, and the lever throws the balance the other way. The balance, therefore, in its isochronal swing, throwing the lever this way and that, and alternately locking and unlocking the teeth of the scape-wheel, determines the rate of movement of the train. This is known as the *patent lever*, *detached lever*, or *detaehed eseapement*.

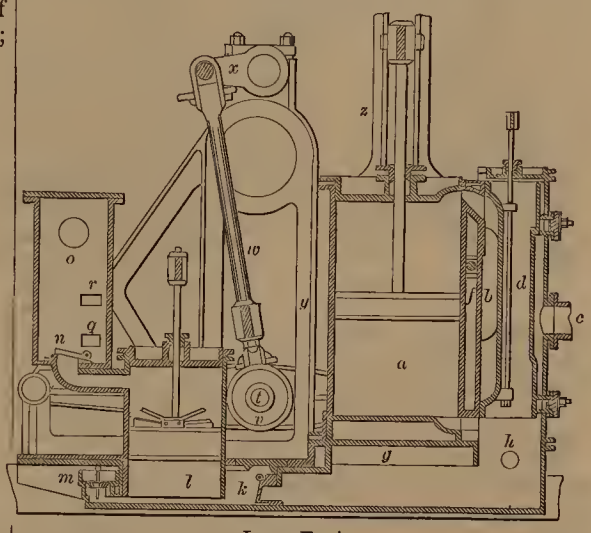
3. (*Surgical.*) An obstetric instrument, curved at its extremity, and having a fenestra. It is used in extracting the head of a child. A *veetis*. See also Obstetrical Forceps.

4. (*Dental.*) *a*. A tool for extracting stumps. *b*. A *turnkey*.

Le'ver-brace. A carpenter's hand-brace.

Le'ver-en'gine. A modification of the *side-beam engine*, in which the beams are levers of the second kind, the fulcrum being at one extremity of the lever

Fig. 2915.



Lever-Engine.

and the piston-rod connection at the other, the connecting-rod to the crank being joined to the beam at a point between the two.

a is the cylinder. *e*, the steam-pipe.

b, the slide-case or valve-chamber.

d, the long slide-valve, whose hollow forms the eduction-passage.

f, the way-shaft by which the valve is worked.

g, the condenser, cast in one piece with the bed-plate, and forming a pedestal to the cylinder.

h, the injection-pipe. *k*, the foot-valve.

l, the air-pump, inserted in a chamber formed in the bed-plate.

m, the blow-through valve. *n*, the delivery-valve.

o, the hot-well.

q r, the passages connected with the feed-pump, one forming the port for the supply of feed-water to the boiler, and the other the port by which the surplus is returned from the pump when the regulating valves or cocks of the feed-pipe to the boiler are closed. See Feed-pump.

t, the lever-beam gudgeon. *v*, the beam.

w, the connecting-rod. *x*, the crank.

y, the side-frame, firmly secured to the bed-plate, and to strong flanges cast on the cylinder.

z, the guides in which the cross-head moves.

Le'ver-es-cape'ment. The *lever*-escapement was invented by Mudge about 1780, and improved by Breguet of Paris and Roskell of Liverpool.

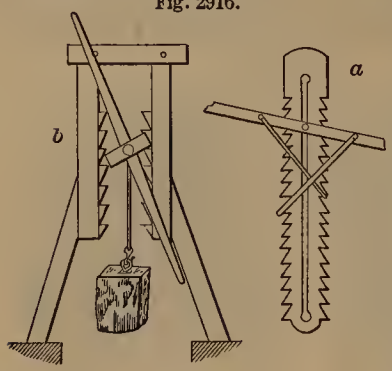
In its first form, the end of the *lever* had a segment-*rack* which engaged a *pinion* on the *arbor* of the *balanee*. The improved form consisted in substituting a *fork* for the *rack*, making what is called the *detaehed lever*, patented by Roskell. (See Fig. 2914.) The lever vibrates on a center and carries the *pallets* (or *anehor*), and its forked end alternately engages with and is engaged by a ruby pin attached to a disk on the balance-arbor. The lever or fork, having the impulse given to it from the wheel, and then striking against the ruby pin, gives

the motion to the balance from which it was disengaged, till brought back by the hair-spring; the ruby pin then strikes the fork and disengages the wheel, thus allowing it to go on.

This causes two distinct beats. See JEWEL.

Le'ver-hoist. (*Hoisting.*) Lagarouse's lever (*a*) is a contrivance for converting a reciprocating circular motion into a continuous rectilinear.

Fig. 2916.



Lever-Hoists.

The device is susceptible of several modifications. In the illustration, it consists of a lever reciprocating vertically on a fixed axis, and having a pair of stirrups which act alternately in the serrations on the respective sides of the rack. As one end of the lever is depressed, one stirrup is made effective, and a dog retains the rack at the obtained elevation. The other end of the lever is then depressed with a repetition of the result stated.

b is a similar arrangement for hoisting, described by the Marquis of Worcester in his "Century of Inventions," 1655, and stated to have been seen by him in the Arsenal of Venice. The cross-bar at the midlength of the lever has a fulcrum on alternate sides of the frame. The teeth are pivoted, and yield as the cross-bar presses against them from below, but afford a safe bearing when the bar rests upon them. The lever is oscillated and each sweep is effective. Several of our lever-jacks are substantially similar.

Le'ver-jack. A form of hoist having a *lever*, *post*, and pawl. See LIFTING-JACK.

Le'ver-ob-stet'ric. (*Surgical.*) *Vectis.* A spoon-shaped instrument employed in certain cases of protracted labor.

Le'ver-press. One of the simplest and most evident forms of pressing apparatus.

It assumes many forms: cider-presses, lard or tallow squeezers, cheese-presses, are constructed to obtain pressure by a lever, which is depressed by a suspended weight, as at *a*, by tackle or by a screw. See OIL, CHEESE, COTTON, HAY-BALING PRESS.

Hebert's oil-press *b* has a standing and a movable jaw with a lever by which the latter is oscillated. Depressions in the faces of the jaws hold the bag of olives, or other oil-producing fruit or seeds. The operator is worth his weight in stones or anything else and something more, as he can climb up to his perch.

c is a cheese-press having a screw for quick motion and a compound lever and suspended weight for continuous pressure. The nut of the screw is boxed in the short lever, which is of the second class. The long lever is of the same class.

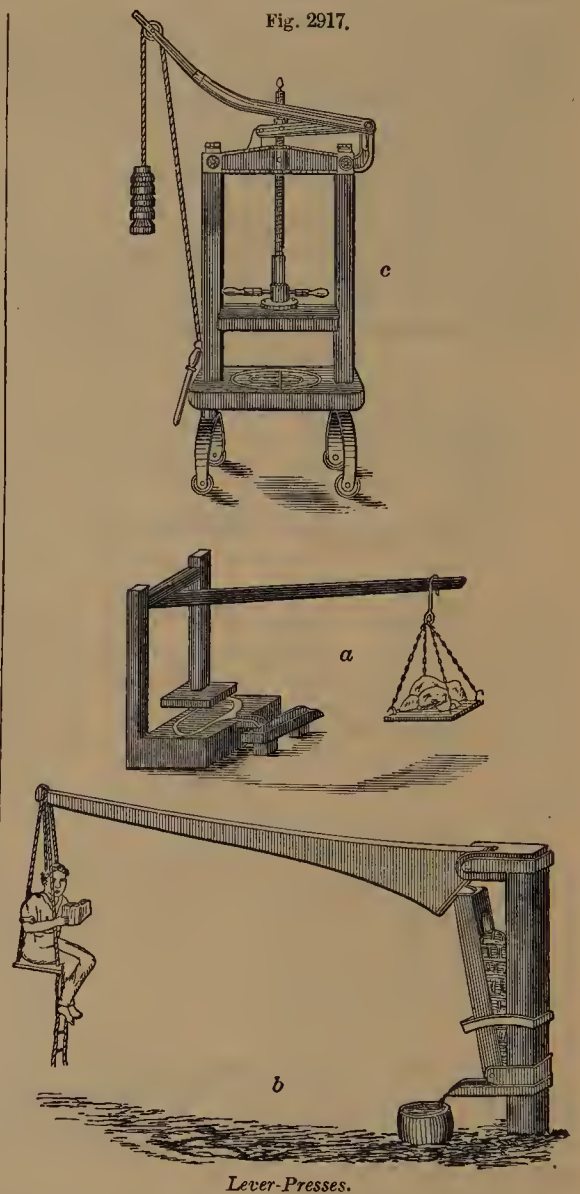
Le'ver-punch. A punch operated by the rolling motion of two cam-faced levers which are approached by a screw.

Le'ver-valve. A safety-valve kept in its seat by the pressure of a lever with an adjustable weight. The invention of Dr. Papin of Blois.

In locomotives a spring is used at the end of the lever instead of a weight; the pressure being regulated by a screw and indicated on a brass plate.

Under ordinary circumstances the valve-lever has a number of weights, which are added as occasion requires, or the weight is shifted in or out on the lever. See SAFETY-VALVE.

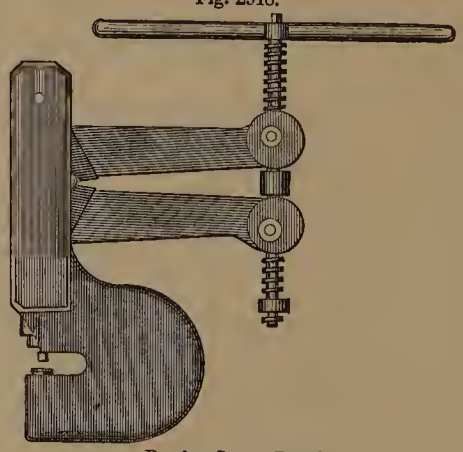
Fig. 2917.



Lever-Presses.

Lev-i-ga'tion. A process of rubbing a moist material between two hard surfaces, as in grinding pigments and printer's ink.

Fig. 2918.



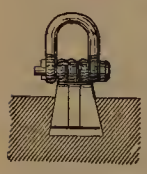
Duplex Lever-Punch.

Trituration is distinguished from levigation in the respect that the material in *trituration* is *dry;* in *levigation* it is *wet.*

When the process is by *muller* and *slab*, it is technically *porphyrization.*

Lew'is. 1. A device for lifting stones which was used many centuries back but received its name from a Frenchman who brought it to its present form. He was an architect on the works of Louis XIV., and gave it the name it bears in compliment to his master. It consists of two dovetail tenons, which are expanded by a key in a dovetail mortise in the stone, and shackled to the hoisting-chain. The dovetail pieces are first inserted and then forced apart by the middle key, so as to occupy the undercut portion of the mortise. All three are then shackled to the lifting-chain.

Fig. 2919.



Lewis.

The *lewis* was used by the ancient Romans, and the peculiar mortise marks are found in the stones of the Flavian amphitheater.

2. A kind of shears used in cropping woolen cloth.

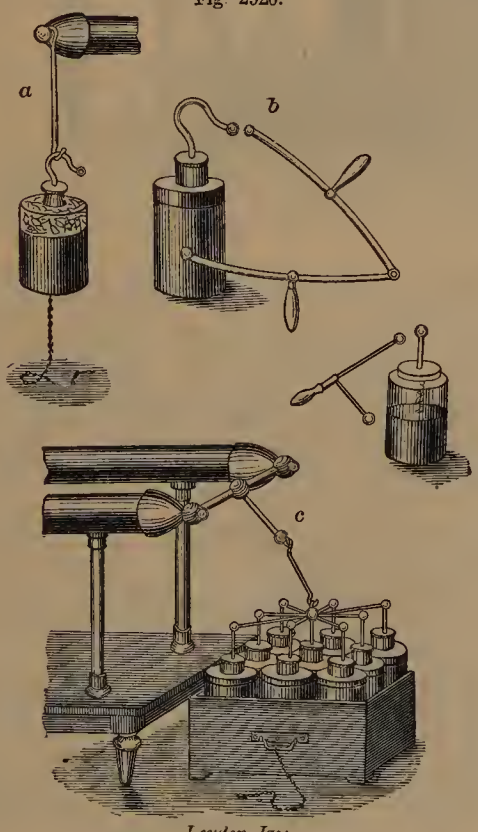
Lew'is-bolt. A wedge-shaped bolt secured in its socket by lead, and used as a *lewis* in lifting. See 7, Fig. 768.

Ley. A solution of an alkali. See LYE.

Ley'den-bat'ter-y. A number of Leyden-jars connected externally by resting on a metallic surface, and connected internally by rods and wires. See *c*, Fig. 2920.

Ley'den-jar. This is a glass jar coated both inside and out with tinfoil, for about four fifths of its hight. The mouth is closed by a cork, through which passes a metallic rod, terminating above in a knob and connected below with the inner coating, either by a chain or by pieces of tinfoil with which the jar is filled. If the inner coating be connected with an electrical machine, and the outer coating with the earth, the former acquires a positive and the latter a negative charge. On connecting them together, by means of a metallic discharger with non-conducting handles, as shown at *b*, a spark is obtained. *c* is a battery formed by connecting together in series all the outer and all the inner surfaces of several jars, so that the united force of the whole is concentrated in the act of discharging.

Fig. 2920.



Leyden-Jars.

The principle of the Leyden-jar was discovered by Muschenbroeck at Leyden in 1745, hence its name. Von Kleist in Germany made the same discovery in the same year.

Gralath in Germany, 1746, contrived the electric battery by combining a series of jars; and finally Drs. Watson and Bevis, by covering the outside of the jar with tinfoil, brought it to the complete state in which we now have it.

The Leyden-jar is a condenser, its two coatings of tinfoil performing the parts of a collecting plate and a condensing plate.

Li-bel'la. 1. A small balance.

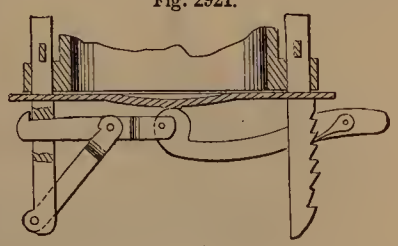
2. A LEVEL (which see).

Lick'er-in. (*Carding-machine.*) A drum with *cards* on its periphery presented at the throat of a carding-machine, so as to catch or *lick in* the cotton filaments as they are presented by the passage of the *lap* between the feed-rollers. See CARDING-MACHINE.

Lid. A cover, cap, or shutter, as of a box; or of the objective or eye-glass of an optical instrument; or of the charging end of a retort; or of the works or the face of a watch; of a hatchway, etc.

Lid-clos'er. 1. A clamp for the covers of gas-retorts, which, after charging, are closed with a luted joint to prevent escape of gas.

Fig. 2921.



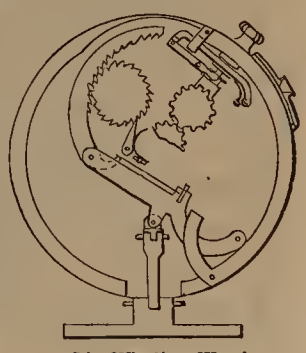
Lid-Closer.

2. Manholes of boilers and tanks are also closed with a bridge-piece and screw.

Lid-wind'ing Watch. One in which the opening of the lid, as occurring several times during the day, is made to wind up the going mechanism.

In the patent of Ramuz, 1868, the cover is connected to a lever which is operated by opening and closing the cover, and acts through a gimbal-joint upon a lever to which a curved ratchet-bar is pivoted. The curved ratchet-bar engages a ratchet-wheel, which communicates with the works so as to partially wind the same when the cover is opened to observe the time.

Fig. 2922.



Lid-Winding Watch.

Theurer's patent of 1866 seems to have been the first of the kind. Mozart's of 1873 may also be noticed.

Lie'ber-kühn. (*Optics.*) An annular reflector attached to the nose of the object-glass, and serving to illuminate an object by reflecting the rays which pass around the object through the slip on the stand.

Lierne. A branch rib introduced between the principal ribs of a groined arch, so as to form an ornamental pattern.

Life-boat. A boat with air-chambers or floats of cork, to give it great buoyancy and allow it to carry a load even when filled with water.

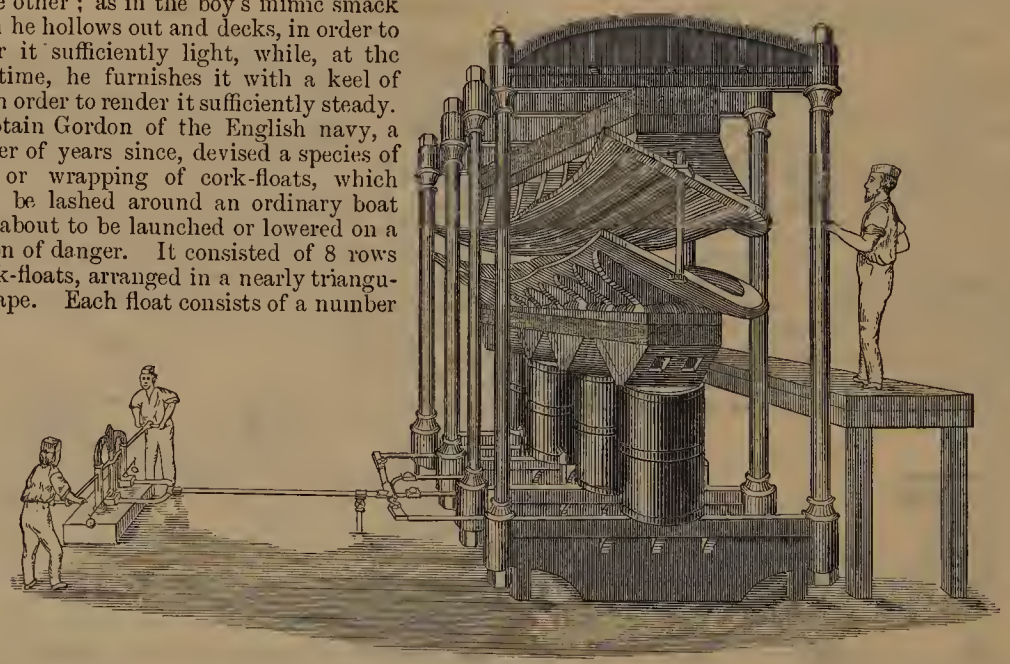
A common boat may be turned to a life-boat by increasing its flotative power. This may be done by bags of cork shavings, packages of cork, inflated bags, air-tight chambers, casks of air, etc. In cases of emergency, various means have been devised by ingenious men under the inspiration of danger or the force of professional training and habit. Brimmer's life-boat, used in England at the close of the last century, had kegs lashed inside the gunwale, bilge-keels, and a keel weighted with iron.

The belemnite, a calcareous fossil, the internal bone of an extinct family of cephalapods, seems to have united the principle of the *float* to that of the *sinker*, as we see it in some of our modern life-boats, which are steadied on their keel by one principle and preserved from foundering by the other; as in the boy's mimic smack which he hollows out and decks, in order to render it sufficiently light, while, at the same time, he furnishes it with a keel of lead in order to render it sufficiently steady.

Captain Gordon of the English navy, a number of years since, devised a species of buoy or wrapping of cork-floats, which might be lashed around an ordinary boat when about to be launched or lowered on a mission of danger. It consisted of 8 rows of cork-floats, arranged in a nearly triangular shape. Each float consists of a number of pieces of cork 1 foot long, 6 inches wide, and 1¼ inches thick, laid three thicknesses together, placed end to end till of the required length, and secured by split bamboo and lashings. The upper strake is the longest, say 9 feet long, and each succeeding strake is 1 foot shorter than the one above it. The strakes are secured together by 4 stout cords, which are seized together between each strake. The 8 combined strakes are so wrapped around an ordinary boat amidships, that the longest strake is just below the gunwale, and the shortest about the keel. The other side of the boat is similarly furnished. For a boat of large class a number of such floats may be provided. Two buoys like that described will displace 14⅔ cubic feet of water, and if added to a boat 28 feet long, and capable of containing 24 men, would leave a buoyancy of 718 pounds for their support.

Luken's life-boat, used in England about 1785, had projecting gunwales and double sides under them, serving as air-chambers, and air-tight chambers under the thwarts or rowers' seats. This arrangement increased the buoyancy and stability of the boat very much.

Fig 2923.



Hydraulic Press.

In 1789, Mr. Greathead of South Shields invented his boat, which proved so successful that it is said that previous to 1804 nearly 300 lives had been saved through its instrumentality near the mouth of the Tynemouth Haven.

This boat was about 30 feet in length by 10 in breadth, and 3¼ feet deep, having a great sheer from the waist to the ends, which were both sharp and rose with a high curve. The gunwale projected several inches, and the sides were cased and lined with cork, secured by sheet-copper and copper nails. The quantity of cork employed was 700 pounds, the outside layer being 4 inches thick, extending along the whole side of the boat; the inside layer was somewhat thicker. The boat was rowed by ten oars, and an oar was employed for steering.

A two-wheeled sling-cart with arched axle was used for transporting the boat to the beach where it was desired to launch it. Mr. Greathead received a Parliamentary grant of £1,200 for his invention, and various rewards from different societies.

Francis's *metallic* life-boats are made between heavy dies, which swage one half the boat at a time by means of hydraulic pressure. The cut is sufficiently plain, requiring no lengthy description. The iron plates are corrugated to insure sufficient stiffness, the dies being grooved to fit each other and give the form to the plate pressed between them.

Water-tight compartments are distributed in different parts of the boat, so as not to be involved in any casualty which occurs in the staving of the boat.

The most important part of the construction consists in the longitudinal corrugations formed in the sheet-metal, by which the strength and stiffness are very much increased.

Francis, in his patent of 1839, describes metallic tubes laid longitudinally in the bottom of the boat, and divided by transverse partitions, which were connected by metallic bands or braces running crosswise of the boat, and which served as floats. Over these the flooring was laid. The framing and planking were laid much as in the ordinary manner. The

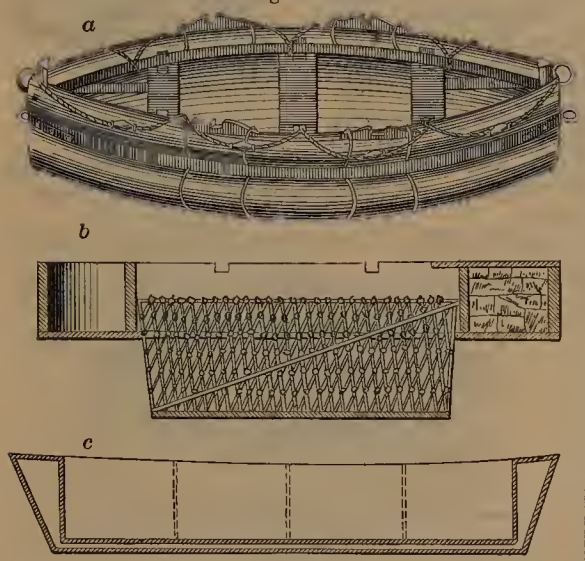
boat was partially decked over at the ends, forming compartments, and had transverse thwarts, between the two middle ones of which was a windlass for raising and lowering the anchor, which was suspended by a cable passing through a hole in the bottom; other holes were provided in the bottom for freeing the boat from water. The boat had a metallic keel.

Noble's life-boat (*a*, Fig. 2924) has a hold covered by a flexible air and water tight covering supported by and fastened to a sustaining frame. This cover may be made double, so as to be inflated and add to the buoyancy of the boat.

The hold is ventilated by a hollow mast with separated passages for the indraft of fresh and the exit of impure air.

In Fig. 2924, *b* represents a boat whose central part has no bottom. The top and bottom of the two end compartments are precisely alike, and act as floats. A net is suspended in the vacant middle space, so that, in whatever position the boat falls

Fig. 2924



Life-Boats.

when launched, persons may be sustained by the suspended net and prevented from sinking; or, in case of capsizing while in the water, may clamber from one side to the other, the net falling to the lower side.

Tier's life and sporting boat (*c*, Fig. 2924) has an inner and outer shell, the space between them being decked over and divided by partitions. The inner shell forms the open space for the boatman.

Another form of boat consists of a cylinder terminating at each end in a conic frustum. It has hinged doors, and is moved through the water by a propeller driven by a shaft having an endless screw turned by gear-wheels worked by hand-crank in the interior of the boat.

A modification of this boat is also cylindrical, and the axes are journaled in a flotative frame, instead of making the cylinder separately buoyant. It is driven by an end propeller worked by a crank in the interior of the boat.

Beeching's life-boat, which received the prize of 100 guineas offered by the Duke of Northumberland in 1850, among nearly 300 competitors, is in form something like a whale-boat. It is about 36 feet in extreme length, 9½ feet in extreme breadth, and 3½ feet in depth. A cork-fender, about 7 inches square, runs around outside a few inches below the gunwale. Extra buoyancy is given by air-cases placed in all the vacant spaces of the boat. These, with the cork-fender, give a buoyancy or upward tendency of more than eight tons, counteracting to that extent the weight or downward tendency of the boat and its crew. For ballast, the boat is provided with water-tanks capable of containing about two tons, and there are pipes for emptying these tanks very quickly. If the boat be upset, the heavy iron keel and the filled water-tanks near the bottom, aided by the light air-cases near the top, tend to right it. It is rigged with a lug foresail and a mizzen. The draft of water, with thirty persons on board, is about two feet; the weight of the boat and its fittings is about three tons and a half, and the cost £250. It is capable of carrying seventy-five persons with safety.

The boat of the National Life-Boat Institution, England, is the invention of Mr. Peake, master shipwright of Devonport Dockyard. It is a strong boat, 30 feet long, 8 feet beam, and rowed by 8 to 12 oars, double-banked. It is nearly flat-bottomed, but the bow and stern rise 2 feet higher than the midship portion. Running along the upper part of each side, and occupying 4 feet at each end, are air-tight chambers, which impart sufficient buoyancy to float the boat and crew when the boat is filled with water. The iron keel weighs 800 pounds, and in connection with the curved shape of the boat infallibly rights the same when upset.

The boat has a false bottom above the water-line, and the space between the two is packed with cork and light wood. Passing through this light stuff are open-ended tubes, 6 inches in diameter, which carry down any water that is shipped by the boat.

The saving of life by life-boats in the British Islands, 1824–65, was 14,980 persons.

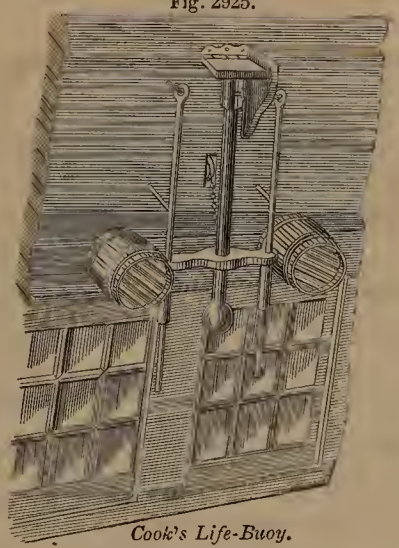
Life-buoy. (*Nautical.*) A buoy or float which is thrown overboard to sustain a person until assistance arrives.

It has various forms: —

1. In one, each of the stools in the cabin has an air-tight tin case fastened beneath the seat.
2. An india-rubber belt capable of inflation.
3. A painted canvas case, of an annular shape, 31 inches in diameter, 6 inches wide, and 4 inches thick. It contains 12 pounds of cork, in thin layers.

Lieutenant Cook of the English navy invented a life-buoy which is provided on board all the vessels

Fig. 2925.



Cook's Life-Buoy.

of that service. It consists of two hollow copper vessels connected by a horizontal bar, through the

middle of which is fixed vertically a strong staff formed of a metallic tube, the upper extremity of which supports the fuse. The lower part of the staff has a balance-weight which drops out when the buoy falls, and maintains the staff upright in the water. The apparatus is kept suspended at the

Fig. 2926.

Life-Buoy.

quarter, is detached by a trigger, and the act of releasing it drops a gun-lock hammer and ignites the fuse, which blazes for a considerable time and attracts the man overboard while it directs the crew of the boat to the assistance of the person. It will support two persons.

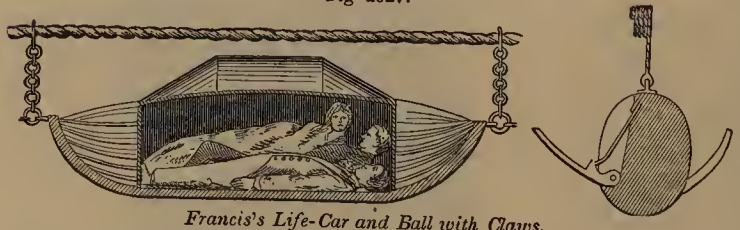
The life-buoy (Fig. 2926) is of similar character. The fuse composition is not extinguished by water.

Life-car. This is an apparatus used to communicate between a wreck and the shore, for the purpose of rescuing persons on board.

Francis's life-car resembles a boat, being a water-tight metallic shell, with a hatchway or cover, and is adapted to travel on ropes whose ends are connected to the ship and to the shore respectively. This connection is made by means of firing from a mortar a shot having a cord attached. The cord is so coiled upon a rack as to pay off freely as the shot is fired and falls beyond the vessel. The cord, being caught by those on board, is made the means for sending ashore a hawser or larger cord on which the life-car may be suspended.

The passengers, to the number of 3 or 4 at a time,

Fig 2927.



Francis's Life-Car and Ball with Claws.

are inclosed in the car, and the trips are made by hauling on a rope attached to the car and grasped by parties on board and ashore.

One of these cars was the means of saving 200 passengers from the "Ayrshire," which went ashore at Long Branch, January, 1850.

Life-guard. (*Locomotive-engine.*) Safeguard, rail-guard, sweeper. The device embracing the brooms fixed in front of a locomotive for clearing small obstructions from the track.

Life-line. (*Nautical.*) *a.* A line stretched above a yard to enable seamen to stand thereon in manning yards.

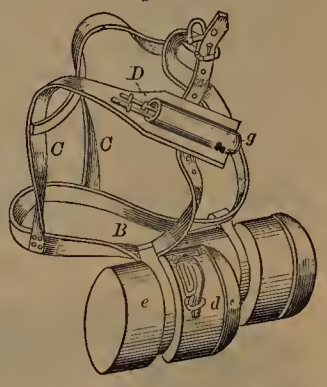
b. A line stretched from object to object on deck, for the men to grasp in bad weather and heavy sea.

c. A line attached at one end to a life-buoy and floating loosely, to assist a person in grasping it.

Life-pre-serv'er. 1. A device to enable a person to float in water in case of accident.

A cork-jacket or inflatable belt or waistcoat are ordinary devices for this purpose. Fig. 2928 shows a more pretentious life-preserver, constructed of two hollow drums or floats, with openings to receive valuable papers or documents, and with depressions *d* to receive the straps *e*. *B C* are the body-belt and shoulder-straps; the pocket *g* is intended to receive a signal-flag.

Fig. 2928.

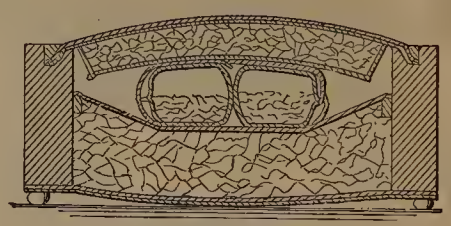


Life-Float.

Besides these articles for wear in an emergency are life-preserving mattresses, seats, berths, buckets, rafts, floats, and, in some cases, the general furniture and even doors of the cabins are specially made to subserve the purpose.

In Fig. 2929, two mattresses filled with cork have

Fig. 2929.



Life-Mattress.

between them an air-bag, confined in a fibrous sack to prevent rupture, the whole forming an elastic bed, which may be separated into several distinct life-preservers in accidents on water.

Life-preservers of cork date back to the time of the early Romans. The Roman messenger sent by Camillus to the Capitol, when besieged, swam the Tiber with a cork-jacket.

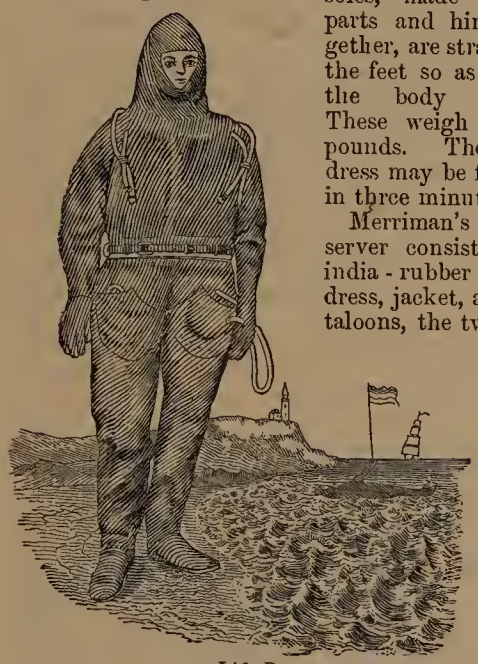
The *bamboo habit*, or Chinese life-preserver, consists of four pieces of bamboo, about a man's length, placed at right angles in parallel pairs, and tied firmly at the four corners, leaving an opening for the body, so that one pair of bamboos rests beneath the armpits.

Captain Manby's apparatus is used in England to communicate with stranded or shipwrecked vessels. A shot thrown by a mortar has a line attached to it, and being thrown over the vessel the line is the means of hauling a rope on board, and thus communication is established with the shore, by hammock or cradle, which is arranged to traverse on the rope. (See LIFE-CAR.) Light-balls are thrown up and explode by fuse at a hight of 300 yards, so as to illuminate a large area and afford a view of the vessel in distress. The apparatus has been the means of saving several hundred lives. Captain Manby died

November 18, 1854, aged 89 years. For apparatus to enable a person to traverse foul air without inspiring it, see INHALER.

Stoner's life-preserver is of india-rubber, and made in one piece, the only openings being in the head-piece and at the wrists; the former is secured by bands passing over the top of the head and a flap under the chin. Suspenders pass over the shoulders from the waist, and an exterior waist-belt is buckled around the body. A cork jacket is buckled arouud the waist beneath the rubber garment, and is prevented from slipping by shoulder-straps. The lower parts of the dress are of thicker material than the upper, and leaden soles, made in two parts and hinged together, are strapped to the feet so as to keep the body upright. These weigh 7 to 8 pounds. The whole dress may be fitted on in three minutes.

Fig. 2930.



Life-Preserver.

Merriman's life-preserver consists of an india-rubber head-dress, jacket, and pantaloons, the two latter connected by a joint, around which is secured a belt to insure the junction being air-tight. It weighs about 14 pounds, and it is said can be inflated in 1½ minutes. The contained air serves to keep the body warm as well as to buoy it up. When in the water the bearer floats upon his back, having about one third of his body above the surface.

With each of these life-preservers is provided a case for holding water and provisions, and a small flag and staff to attract attention.

Ormsbee's life-preserver consists of inflatable sleeves, leggings, hip-bands, which may be worn with but little inconvenience when in positions of danger, or in learning to swim. Or they may be carried in the pocket.

2. A loaded stick or cane with a leaden head, used as a protection against assailants.

Lift. 1. (*Nautical.*) A rope stretching from a mast-head to the end of a yard, to *trim* it (*squaring*), or in *topping* (*yards apeak*).

A *topping-lift* is a rope which raises the after end of a boom.

2. A hoisting-machine. See list under HOISTING. *a.* An elevator for goods or material in a furnace or mine. See ELEVATOR; FURNACE-HOIST; MAN-ENGINE, etc.

b. A *dumb-waiter.*

3. An exercising machine. See LIFTING-MACHINE.

4. The distance which an ore-stamp rises and falls.

5. (*Lathe.*) One of the several flats or grooves for the belt on the driving and cone wheels of a lathe. The varying diameters of the lifts are for changes of speed.

6. (*Shoemaking.*) One thickness or layer of leather in the *tap* which forms the heel of a boot.

7. (*Hydraulic Engineering.*) *a.* The amount by which a canal-boat is elevated in a lock. The difference in level between the upper and lower *pounds.*

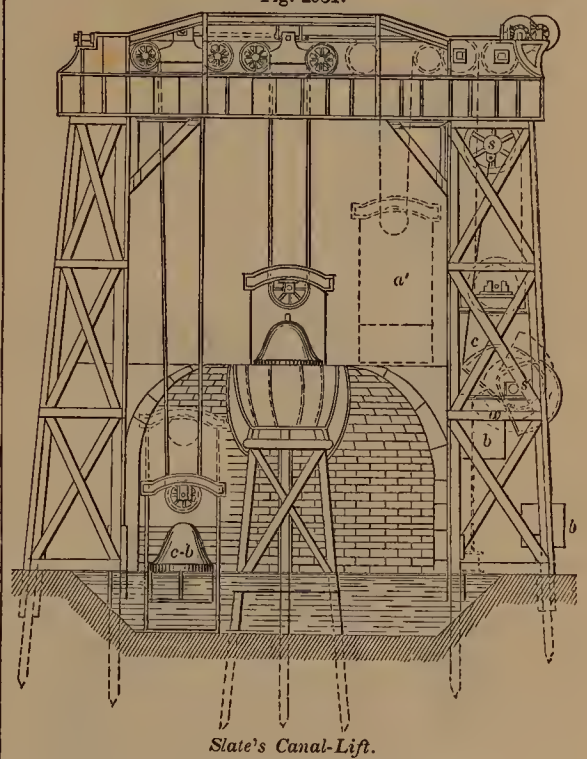
b. The rise of an undershot-wheel above the water-surface.

c. A substitute for canal-locks, the boats being lifted and lowered by machinery from level to level.

The boats are floated in water during transfer; gates and sluices in the main *line* are dispensed with; the boat is transferred from one level to another without loss of water.

The lower level is divided into two branches, which are carried along each side of the upper level to a length a little over that of the canal-boat. The depth of each branch is sufficient to allow the boat *c-b* to float over the top of an iron caisson or tank *A*, filled with water and sufficiently large to float a loaded boat. An elevated framework is constructed to overarch the three basins, and is provided with transverse rails and carriages, containing the wheels over which run the suspending chains by which the caissons, their contained water, and the floating boat are lifted or lowered. The caissons, which lie in the bottoms of the basins to receive their load, are suspended by straps from cross-bearers, to which the suspending chains are connected. The chain which suspends one caisson and boat passes over drums on one carriage, and that which suspends the other caisson and boat passes over the drums on another carriage; the chain at each end of the lift being the same, passing in continuity over the different drums and around the long shaft at the side of the framework, so that, as the shaft revolves, the chain winds on one set of drums and unwinds from the other, one boat rising as the other descends.

Fig. 2931.

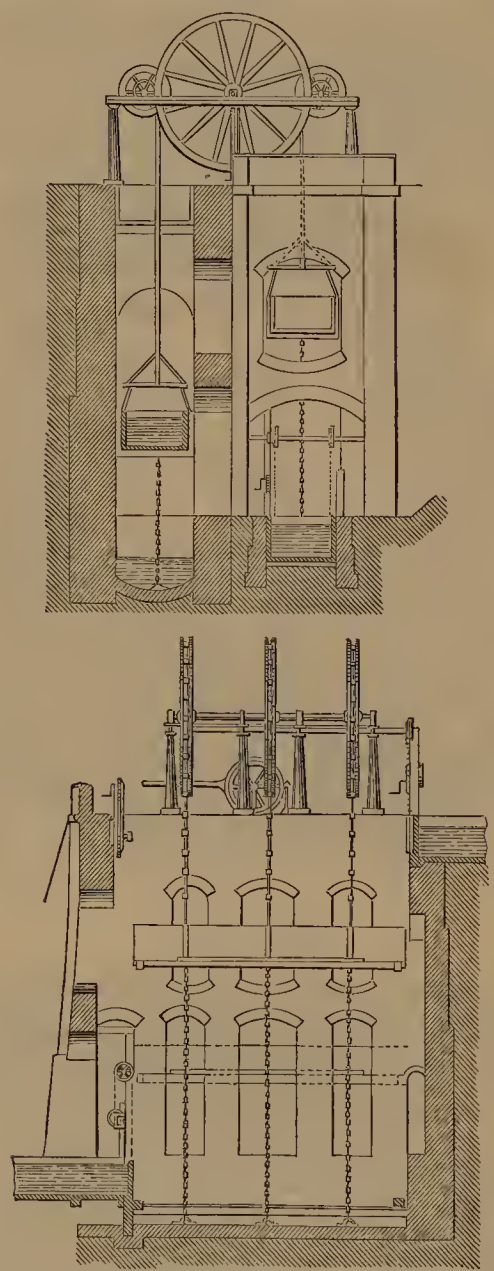


Slate's Canal-Lift.

The action is as follows: —

Two boats approaching the lift from contrary directions are floated over the sunken caissons in the lower and upper basins respectively. The load is uniform, whether the caisson contain a boat or otherwise, as the caisson is full of water in either case, and the boat displaces a weight of water exactly equal to its own weight. The shaft *s'* is rotated by steam or water power, and the chains wind on the cams *c c*, causing the upper shaft *s* to move down in the framework and draw the caissons with their

Fig. 2932.



Canal-Lift (*Great Western Canal of England*).

loads out of the water. The weight of the caisson is balanced by a weight *w*, which acts by a short or long leverage on the cams, according to the position of the caissons in or out of the water respectively. The buckets *b b* suspended from the shaft *s'* may be filled as required to assist the power in working the shaft.

The caissons being lifted out of the water, the upper caisson is moved on the railway across the canal, so as to be suspended over the lower basin, ready to descend.

When in this position the two caissons are in equilibrium, each suspended clear of the water, and over the lower basin, the upper one occupying the position in dotted lines *a'*. The equilibrium is then disturbed, by allowing some water to escape from the lower caisson, which thereupon rises, the positions of the respective caissons changing. The lately raised caisson is then moved over the upper basin by the traversing of its carriage on the railway above. Now all is in order for the descent of the caissons into the respective basins. The power is then applied to the shaft *s'* which allows the shaft *s* to rise, and the caissons are lowered simultaneously, the boats are floated over the ends of the caissons and resume their journeys.

On the Great Western Canal of England lifts are employed, 46 feet in hight and consisting of 2 chambers with a pier of masonry between them. Each chamber is of sufficient capacity to contain a timber cradle, in which the ascending or descending boat is placed. The cradle, when on the level of the canal, allows the boat to float into it by raising a watertight gate at one end. The two cradles which work in the chambers, when full of water or when both or either of them contain a boat, balance each other on strong chains, which pass over 3 cast-iron wheels, and are so arranged that the water in the upper cradle is kept about 2 inches below that in the pond, which gives it a slight preponderance, sufficient to set the machinery in motion. The boats weigh 8 tons, and pass up or down the lift of 46 feet in about 3 minutes, consuming 2 tons only of water.

The upper view (Fig. 2932) is half a front view and half a transverse section of this lift. The lower view is a longitudinal section.

Lift-bridge. A bridge designed to lift to allow a canal-boat to pass, when the viaduct is but a short distance above the water-level. It is hung by the four corners to four chains, which pass over pulleys and have counterpoises at their other ends.

Lift'er. 1. (*Paper-making.*) A cast-iron wheel with buckets revolving in a case, lifting pulp from the reservoir or *pulp-chest*, and passing it to the trough, from whence it flows on to the traveling web. On the latter it is shaken, partially drained of its water, and is then delivered by the *coucher* to the first pair of pressing-rollers.

2. An elevator or hoisting-apparatus.

3. (*Steam-engine.*) The arm on a lifting-rod that raises the puppet-valve.

The upper portion of the figure (2933) is a top view of a Western steamboat engine, the lower portion is a side elevation on a somewhat enlarged scale. The lifter is shown in the middle, having curved surfaces at the points of contact with the valve-levers.

4. (*Founding.*) A tool used by a molder in elevating the *cope* from the *drag*.

5. *a.* A domestic tool for raising or adjusting the lids of a stove.

b. An implement for holding hot plates or dishes.

6. (*Surgical.*) A *levator* or lifting lever used in injuries to the cranium. It belongs to the trephine case. An *elevator*. The forms are four; known as the *common*, Louis', Petit's, the triploid.

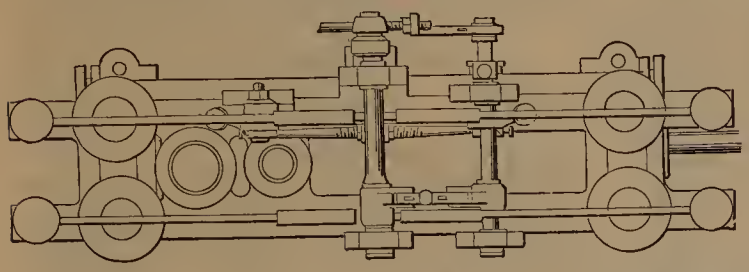
7. A *cam* or *wiper* used in raising a stamper or beetle, or in depressing the tail of a tilt-hammer helve.

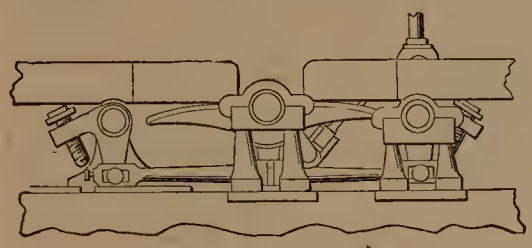
Lift-gate. A gate which lifts instead of swinging on a pintle, as, —

A portcullis.

A farm-gate counterbalanced, and rising in guides, like a sash.

Fig. 2933.



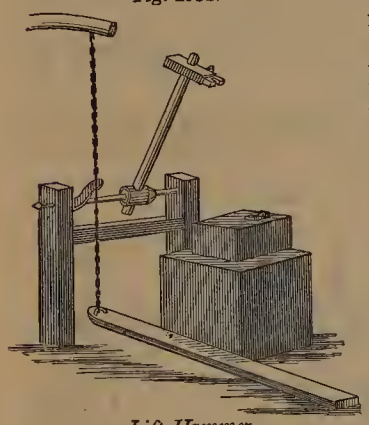


Valve-Lever Lifter.

A canal-lock, graving-dock, or sluice-gate which rises in vertical grooves in the walls.

Lift-ham'mer. The lift-hammer is a light form of tilt-hammer in which the hammer is raised by a spring and depressed by a treadle. When the hammer has a head of depressed contour, acting in concert with a counterpart tool on the anvil, it becomes a swage, the top and bottom tools answering to those of a *drop*. For this purpose, the vertical movement is preferable.

Fig. 2934.



Lift-Hammer.

The intention of the apparatus is to enable the blacksmith to dispense with an assistant, a *striker*, but it has not come into extensive use and is not likely to. It is asking too much of one man to attend to both operations skillfully.

Lift'ing-bar. 1. (*Knitting-machine.*) A horizontal rod or bar having a short intermittent vertical or nearly vertical reciprocation, and which at the proper moment operates to lift the *jacks*.

2. (*Weaving.*) The movable frame of a Jacquard loom in which the lifting-blades are fastened.

Lift'ing-blade. (*Weaving.*) An iron rule to receive the lifting-wires of a Jacquard loom when hoisted.

Lift'ing-bridge. The *lifting-bridge* is the simplest of all drawbridges, being merely a platform hinged to the bank, curb, or scarp at one end, the other being lifted by chains or cords worked by windlass or weights. It is used in crossing the canals in Holland, where the roadway is nearly on a level with the water.

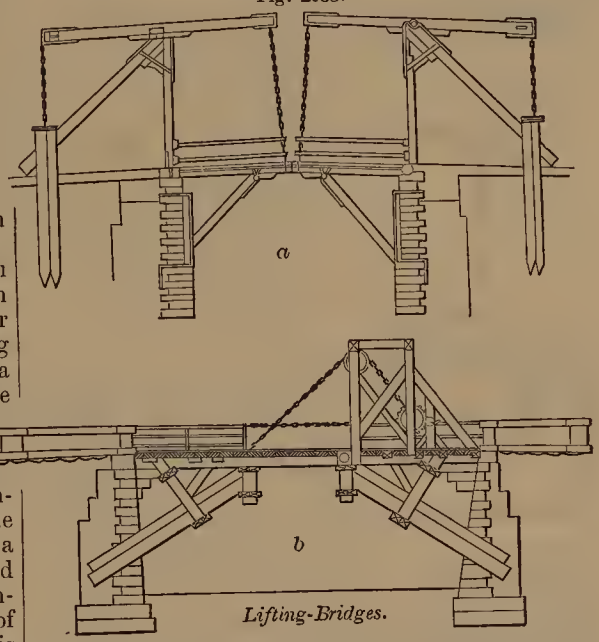
It is also used in fortifications.

The drawbridges (*a*) of Brussels were balanced by weights attached to chains passing over standards that stood immediately over the walls of the canal, and were braced and stayed by timbers and iron ties. The weight of the draws was borne by struts beneath, which were footed in set-offs in the faces of the masonry, and rested at their upper ends against jogs beneath the sill-timbers of the bridge.

Perronet, the great French engineer, 1708–94, was the chief engineer of the *Ponts et Chaussées* from 1747, and did more for the science of bridge-building than any of his contemporaries.

He contrived a drawbridge (*b*) which had a short middle draw to allow the masts of vessels to pass when the headway beneath the bridge was sufficient for the hulls of the vessels. This middle section is hinged to one portion of the bridge and lifted by a chain and winch.

Fig. 2935.

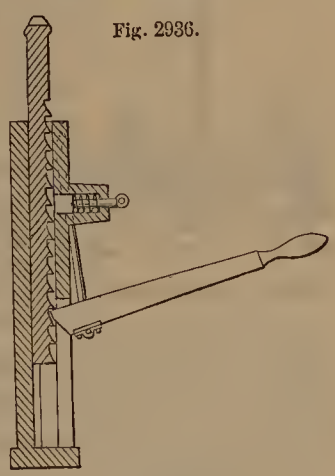


Lifting-Bridges.

Lift'ing-gear. (*Steam-engine.*) The apparatus for lifting a safety-valve from within a boiler. It consists of levers connected to the valve and to a screw worked by a handle outside the boiler. See LIFTER.

Lift'ing-jack. A hoisting-implement operated by a lever, a screw and lever, or by hydraulic pressure. The figures show forms of the *lever-jack*. For other varieties, see list under JACK.

Fig. 2936.



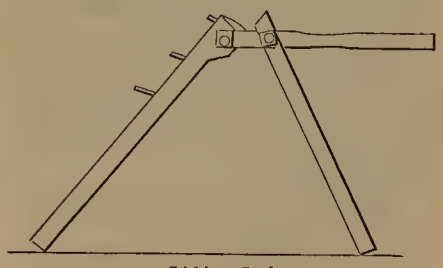
Lifting-Jack.

Fig. 2936 has a rack-bar raised by a lever pivoted in a strap, and the rack is sustained by a sliding spring catch.

In Fig. 2937, the upper ends of the legs are connected by a lever, by whose depression they are erected and the wagon-axle raised.

In Fig. 2938, the fulcrum-pin of the lever rests in rounded notches in the standard, and is held down by an extension pawl which is pivoted to the stand-

Fig. 2937.



Lifting-Jack.

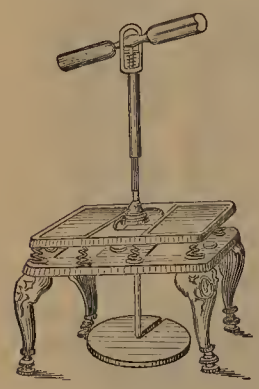
Fig. 2938.

Lever-Jack.

ard and engages a ratchet on the upper side of the lever.

Lift'ing-ma-chine'. An exercising-machine belonging to the furnishing of a gymnasium, in which a weight is so disposed with handles or straps for the hands, hips, or shoulders, that a person may conveniently try his strength, and improve by persistent trying at gradually increasing weights. Weights or springs are used, sometimes in connection with a dynamometer, to indicate the force exerted.

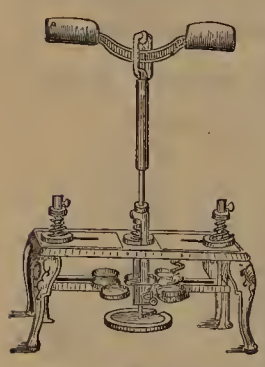
Fig. 2939.



Weight Lifting-Apparatus.

Fig. 2939 shows Butler's standard health-lift, giving a dead-weight lift softened by spring-action. The platform on which a person stands in lifting rests upon ten volute springs on the frame, the legs of the frame resting also on volute springs on the floor. Rubber cushions and cartilages soften every movement. Through the center of the machine passes an upright rod, having at its upper end a stirrup through which the handle is passed transversely, while at the lower extremity, beneath the platform, is a disk to receive the weights, of from one to fifty pounds each. The handle passes through springs at the platform level, which sustain the weight and gradually release it as it is lifted clear. Weights to the amount of 600 pounds are provided. The machine occupies a space of 26 × 32 inches on the floor; 26 inches to the top of the platform. The person stands a-straddle of the handle, and lifts with one hand in front and the other in the rear.

Fig. 2940.



Spring Lifting-Machine.

Fig. 2940 is a machine in which graduated springs are substituted for weights.

Many other forms of exercising-machines are used, some for the bedridden, some specially adapted for victims of spine disease, some for general exercise of the muscles to improve the tone of the system. See EXERCISING-MACHINE.

Lift'ing-piece. (*Horology.*) A lever having a tooth which engages in notches in the *count-wheel* to restrain the striking. The *count-wheel* has 78 divisions, and notches are cut in it at the successive distances of 1, 2, 3, 4, etc., of the divisions. The lifting-piece being raised by a pin or a snail on one of the hour-wheels, the tooth of the lifting-piece rests on the rim of the count-wheel until the prescribed number of blows is given, according to the length of the space between the notches.

Lift'ing-pump. One by which the liquid to be raised is lifted instead of forced from its receptacle to the point of discharge. To this class belongs the ordinary atmospheric pump. The chain-pump and similar devices may also be included. The atmospheric pump was probably known to the ancient Egyptians, and by them handed down to the Greeks and Romans, by whom it was little used.

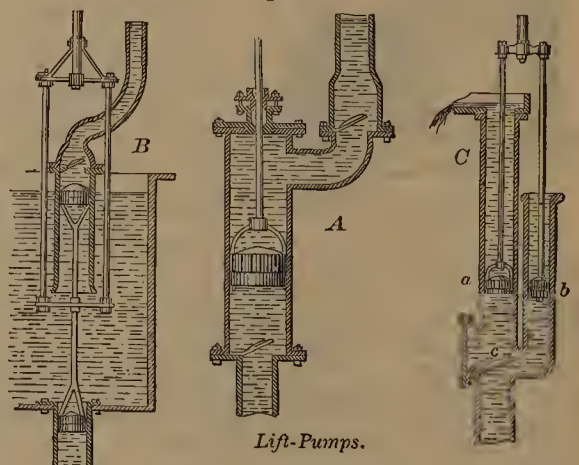
The principle was explained by Torricelli, the pupil of Galileo, whose attention, as well as that of his master, was drawn to the matter by the unsuccessful efforts of the Florentine pump-makers to raise water by its means to a hight much over 30 feet. In fact, at elevations above the sea-level, it can only be lifted to a hight in feet about equal to the number of inches at which the mercury in the barometer stands; one inch of mercury corresponding to about 13 inches of water. See LIFT-PUMP.

Lift'ing-tongs. The tongs with concave jaws used in grasping crucibles. See CRUCIBLE-TONGS.

Lift-pump. *A* (Fig. 2941) shows one form of modern lifting-pump. The head of the pump is closed, and the water may be lifted through the side tube to any elevation consistent with the strength of the tube.

B is a double-piston pump adapted to situations where the pump cannot be conveniently inserted in the reservoir. The piston of the atmospheric pump is directly under that of the lifting-pump, and works in a cylinder attached to the bottom of the cistern. Each is attached to the same rod and worked by the same frame.

Fig. 2941.



Lift-Pumps.

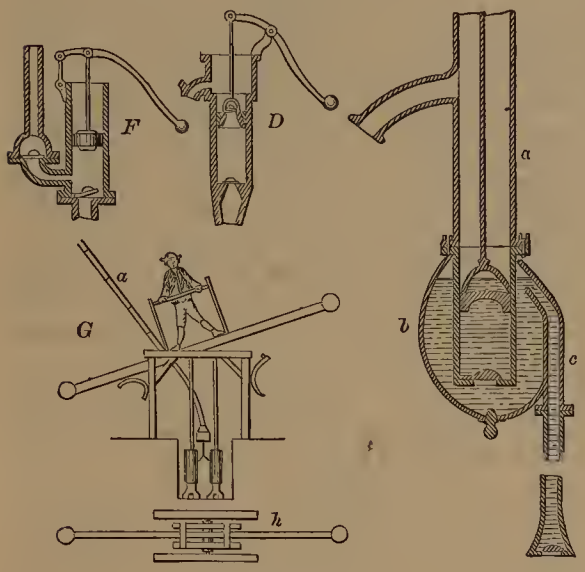
In *C* two pistons *a b* are placed in two cylinders, side by side, and are operated simultaneously by attachment to a cross-head, both drawing up the water at the same time. The downward movement, as it closes the valve *c*, forces the water upward through the cylinder *a*, maintaining a continuous discharge.

D (Fig. 2942) is an atmospheric pump. The upper valve is of peculiar construction.

F is a solid-piston pump, which lifts the water to the barrel, and on its downward stroke forces water up the pipe.

G is a double-cylinder balance-beam pump. The pistons are alternately raised and lowered by a man

Fig. 2942.

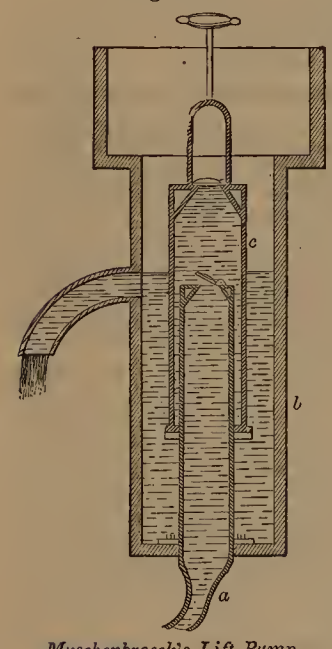


Lift-Pumps.

throwing his weight alternately on either side of the beam, and discharge the contents of the cylinders through the pipe *a*. *h* is a plan of the beam and its frame, on which the man stands.

In Lecorche's pump (to the right), the cylinder *a* is surrounded by an air-tight vessel *b*, which, being originally filled with water to a hight sufficient to cover the piston, always keeps the valve wet. Each stroke creates a vacuum in the vessel *b*, causing the water to rise in the cylinders *a c*, whose valves are lifted at the same time. This arrangement also obviates the shock caused by the water when the piston is worked rapidly.

Fig 2943.



Muschenbroeck's Lift-Pump

Fig. 2943 is a pump described by Muschenbroeck. The upper end of the suction-pipe *a* enters a small cistern *b*, and is surrounded by a cylinder *c*, the lower part of which fits closely around it. The valves of both open upwardly. The upward movement of the cylinder *c* causes a vacuum in both it and *a*, which become filled with water, the downward movement of *c* causing the water therein to overflow into the cistern *b*, whence it is discharged.

Lift'ing-rod. (*Steam-engine.*) A rod receiving motion from the rock-shaft, and imparting motion to the *lifter* of the puppet-valve.

Lift'ing-screw. A form of hoist in which a screw is used. See JACK-SCREW.

Lift'ing-set. The series of pumps by which water is raised from the bottom of a mine by successive lifts. See CORNISH ENGINE.

Lift'ing-wires. (*Weaving.*) The wires by which the warp-threads are raised and lowered to produce the pattern in a Jacquard apparatus.

Lift-latch Lock. (*Locksmithing.*) A lock in which the latch is pivoted and *lifted* free of the keeper, passing through a notch in the box, instead of being simply retracted.

Lift-lock. (*Engineering.*) A canal-lock, in which a boat is *lifted* by the introduction of water, so as to raise it to the upper level. See LIFT, 7.

Lift-tent'er. 1. A contrivance adopted in European windmills for regulating the distance apart of the mill-stones, according to the speed of the vanes. It is of the nature of the steam-governor, having suspended balls which fly out by accession of speed, and thus act upon the *bridge-tree* by which the runner is supported.

2. A ball-governor arrangement to regulate the speed of a windmill's vanes. This use of the contrivance preceded that of its application to the steam-engine.

Lift-wall. (*Hydraulic Engineering.*) The wall at the head of a canal-lock chamber. See CANAL-LOCK.

Lift Wa'ter-wheel. 1. An under-shot wheel.

2. A water-wheel whose gudgeons and bearings may be raised or lowered to adapt it to varying hights of water supply.

Lig'a-ting-for'ceps. A pair of grasping fingers protruding from a sleeve and closed by retraction into the sleeve. Other forms are used, the specific construction depending upon the nature of the operation and the size of the available opening for its application.

Lig'a-ture. 1. (*Printing.*) Two or more letters cast on one shank ; as ff, ffi, etc.

This was formerly very common, and was carried to an excess by Earl Stanhope, who called them *logotypes*.

They are now confined to some diphthongs and the &, which is derived from &, the *logotype* of *et*.

2. (*Surgical.*) *a*. A thread to tie arteries or veins.

b. A wire cord or thread used in removing tumors, etc. See ECRASEUR.

c. The bandage used for phlebotomy.

Galen recommends silk thread for tying blood-vessels in surgical operations.

The ligation of the femoral artery was first performed by Hunter, about 1785.

That of the external iliac by Abernethy, 1796.

The internal iliac by Alexander Stevens, in 1812.

The common iliac successfully by Dr. Valentine Mott, in 1827.

The common carotid by Sir Astley Cooper (successfully), in 1808.

The innominata by Mott in 1818, and successfully by Dr. J. W. Smythe in 1864.

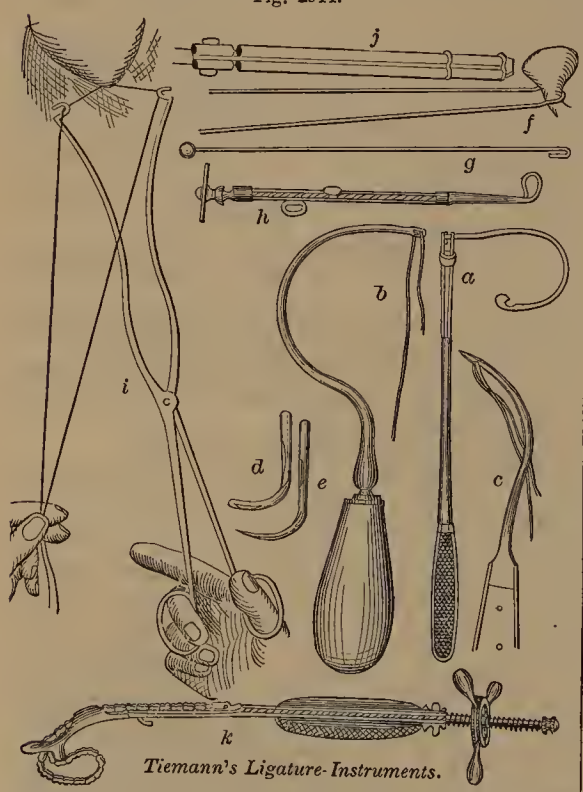
"Ambrose Paré, born at Laval, in France, in 1509, was a member of the fraternity of barber-surgeons ; but, such was the reputation he acquired as an operator, he was made surgeon to four successive sovereigns of France, and, among others, to the weak and cruel Charles IX., by whom, however, although Paré was a Huguenot, his life was saved on the terrible night of the massacre of St. Bartholomew, by detaining him in the royal chamber until morning. With Paré, who lived little more than 300 years ago, we may commence to date the achievements and triumphs of modern surgery. Hitherto, after amputations, the bleeding-vessels had generally been secured by searing them with cauterizing irons, or by dipping the end of the stump in boiling oil or molten lead. Paré revived the ligature, which, although it had

been suggested, and probably adopted in a few cases several centuries before, had been forgotten or abandoned by his immediate predecessors. Such was the mortality under the old process of securing the vessels, that Guy de Chauliac declared it was better to let the limb drop off than to amputate it with the knife; and he advised ligating firmly at the nearest joint, and thus to cause gangrene and sloughing of the limb below. Since Paré wrote, great improvements have been made in the application of the ligature, and its usefulness has been greatly extended; especially is it proper to mention its application for the reduction of vascular tumors, including elephantiasis, for the relief of epilepsy, and for various other maladies in which it is known that organs are suffering from an excess of blood; but the greatest achievements of the ligature have been in the cure of aneurisms." — F. H. HAMILTON, M. D.

The ligature occasions obliterations or adhesion of the arterial parietes by cutting through the middle and internal coats, the adhesion being favored by the formation of a coagulum, which acts in some degree as a barrier against the impulse of the blood, and subsequently disappears by absorption.

Lig'a-ture-car'ri-er. A surgical instrument with a bent stem for passing a ligature around an artery

Fig. 2944.



Tiemann's Ligature-Instruments.

which is to be ligated, a bone which is to be divided by a chain-saw, or other object which is to be cut.

In the absence of special instruments therefor, the duty is performed by a curved needle carrying a thread.

a, Fig. 2944, is Post's chain-saw carrier. *b* is Tiemann's instrument to carry ligature for chain-saw. *c* is an aneurism needle. *d e* are Mott's aneurism needles. *f g h* are Van Buren's artery-ligating instruments. *i* is Carrol's knot-tyer. *j* is Gooche's double cannula for uterine polypus. *k* is Charriere's lengthened chain-ecraseur.

Lig'a-ture-ty'er. An instrument to carry flax or silk thread, or silver wire, for tying off arteries, aneurisms, tumors, polypi, or piles, etc. See Fig. 2944, LIGATURE-CARRIER.

In Carrol's ligature-tyer (*i*, Fig. 2944) the ligature, being held by the blunt hooks, which are at right angles to the branches, is readily passed around the tumor, and the instrument withdrawn; a single knot is tied, which is easily slid up to the tumor and tightened, the instrument operating after the manner of a glove-stretcher. A second knot is tied in the same manner, and with almost as great facility and rapidity as could be achieved by the fingers in an accessible situation. It might also be of service to tighten a ligature upon a vessel at the bottom of a deep wound where the fingers cannot be readily used.

When the artery alone is tied, the ligature is said to be *immediate*. When any of the surrounding parts are included, it is said to be *mediate*.

Lig'ger. A line with a float and bait laid for night fishing.

Light. 1. An illuminating body, as a burning candle, lamp, etc. As lime, calcium, electric, Drummond, oxyhydrogen, etc., light. See list, *infra*.

A calculation of the respective values and costs of different lighting materials is as follows: —

Six mold candles weighing one pound will burn forty hours, if lighted in succession. One gallon of sperm-oil, burnt during the same time, will give a light equal to fifteen of such candles. Twelve cubic feet of gas will give a light equal to the six candles during the same time.

Prices vary at times, and that of gas varies from $1.70 to $7.00 for 1,000 feet in different parts of the United States, but at the prices annexed the following will be a comparative statement for forty hours' burning of an equal power: —

15 pounds of sperm-candles, at 20 cents	$3.00
1 gallon sperm-oil, at $2.00 . .	2.00
180 cubic feet of gas, at $3.00 . . .	.54

2. (*Nautical.*) A burning lamp, cluster of lamps, or beacon fire, serving as a warning and guide to mariners arriving off a coast or in the neighborhood of dangerous rocks or shoals. See LIGHTHOUSE.

It is usually displayed from a tower, called a lighthouse, and has several variations, incident to the mode of production or emission and direction, and to the visible characteristics by which the mariner distinguishes one light from another when arriving off a coast, so as to ascertain his geographical position, and his bearings as to his port or course.

In early times the light was a fire of burning wood. Such were the lights of the famous Pharos of Alexandria, and the Tour de Corduan at the mouth of the Garonne. In 1812, the Lizard Point light, Cornwall, England, was maintained with coal fires. The same may be said of the Isle of May light, Frith of Forth, Scotland, in 1816. This, in fact, was the usual light at that time in positions readily accessible.

The Eddystone light first consisted of tallow candles stuck in a hoop, and afterwards of twenty-four wax candles.

The *Argand lamp*, invented in 1784, and bearing the name of its distinguished inventor, rendered a better light possible. See ARGAND.

It was introduced into the Tour de Corduan soon after its invention, and associated with paraboloid reflectors in a revolving frame. This is the *catoptric* system, invented by Tulère of the French Royal Engineers of Bridges and Roads. See CATOPTRIC LIGHT.

Argand burners and paraboloid reflectors were substituted for wax candles in the Eddystone lighthouse in 1807.

In the *dioptric* light the beams are transmitted through lenses, instead of being reflected by mirrors.

Lenses were adopted in some lighthouses about 1752–59, but owing to the imperfections of glass and manufacture, they were not in much favor till the improvements of Fresnel about 1810. See DIOPTRIC LIGHT.

The *cata-dioptric light* is a combination of the two, as its name indicates. See CATA-DIOPTRIC LIGHT.

The *oxyhydrogen light* and the *voltaic light* from carbon points have been proposed, owing to their brilliancy. See ELECTRIC LIGHT.

The term *leading-light* indicates such a disposition of two lights on distinct towers as to indicate a course, a channel, or a danger. See LEADING-LIGHT.

A *floating* light is one at the mast-head of a vessel moored on a spit or shoal where no adequate foundation exists for a permanent structure. See FLOATING-LIGHT.

The characters of the light furnished to the mariner are varied, so that when he comes in sight of a given light he may tell by its color or behavior where he is.

These distinctive lights are thus enumerated: —

Fixed.	*Flashing.*
Revolving.	*Colored.*
Intermittent.	*Double.*

The *fixed* light gives a constant and steady radiance.

The *revolving* light is produced by the revolution of a frame with three or four sides, having reflectors grouped on each side with their axes parallel. The frame rotates once in a minute, or once in two minutes, as may be required, the light fluctuating between full strength and total darkness, the changes being gradual. See REVOLVING-LIGHT.

The *intermittent* light is produced by the perpendicular motion of circular shades in front of the reflectors, by which the light is alternately hidden and displayed. The alternations of light and darkness are sudden, and occur at intervals of about thirty seconds.

The *flashing* light is produced by a revolving frame, the mirrors of which are arranged on 8 sides. The reflectors on each side are arranged with their rims or faces in one vertical plane, and their axes in a line inclined to the perpendicular. This disposition, in connection with the rate of motion, gives a flash of light every 5 seconds, alternating with comparative dimness. There is no eclipse, but a pulsating effect; bright and dim, bright and dim.

The *colored* light may be of various colors, but for important situations and distant view *red* is alone used. A variety is given in revolving lights by alternating *red* with *two whites* or *one white*, or *two reds* with *one white*. Also by associating a *red* and a *white* light in a *double light*.

Colored media absorb so much light as to detract from their usefulness. They have been generally discarded in French lighthouses.

The *double* light is exhibited from 2 towers, which may be of equal hight, but usually differ in hight. It is used as another mode of marking a particular headland, as at the Lizard Point and Calf of Man, in British waters. It also affords a *leading* light, as the conjunction of the two lights in one line is made to indicate a course or a warning. See DOUBLE LIGHT.

These lights may be variously combined. The catoptric admits of the following variety: —

1. Fixed.
2. Revolving white.
3. Revolving red and white.
4. Revolving red with two whites.
5. Revolving white with two reds.
6. Flashing.
7. Intermittent.
8. Double fixed.
9. Double revolving.

The variations in the dioptric lights are *fixed* and *revolving;* the main distinctions of the latter being founded upon the time between flashes.

According to the British and French regulations, vessels, between sunset and sunrise, are ordered to carry lights as follows: —

A *green* lamp on the starboard side and a *red* light on the port side, visible throughout an arc of 10 points from right ahead to 2 points abaft the beam. An inboard screen prevents the light from being seen from the opposite side. Steamships, in addition, carry a white light at the foremast head, visible through an arc of 20 points, extending between points 2 points abaft the beam on each side.

Steam vessels towing other vessels to carry *two* foremast head-lights, in addition to the side lamps.

Vessels at anchor to carry a white light, visible all round, and not exceeding 20 feet above the hull.

3. (*Shipbuilding.*) An opening in the deck or side of a vessel, as *deck-light*, etc.

A *side-light* is also known as a *light-port.* The water-tight shutter by which it is protected in stormy weather is known as a *dead-light.*

4. A pane of glass.

Light and Pho'tic Ap-pli'an-ces. See under the following heads: —

Aphlogistic lamp.
Argand-burner.
Argand-lamp.
Argand gas-burner.
Astral-lamp.
Beale-light.
Bengal-light.
Blue-light.
Boccius-lamp.
Bracket.
Branch.
Bude-lamp.
Bull's-eye.
Burner.
Calcium-light.
Candelabrum.
Candle.
Candle-mold.
Candle-stick.
Carbon-light.
Carbureting-machine.
Cata-dioptric light.
Catoptric light.
Chandelier.
Cigar-lighter.
Clock-work lamp.
Colored light.
Cresset.
Cric.
Dark-lantern.
Davy-lamp.
Deck and side light.
Deflector.
Dioptric light.
Döbereiner's lamp.
Double light.
Drop-light.
Drummond-light.
Electric light.
Electrophorus.
Extinguisher.
Fan-light.
Fantail.
Fishtail-burner.
Fixed light.
Flashing-light.
Flash-pipe.
Floating-light.
Foot-light.
Fountain-reservoir lamp.
Gas.
Gas-alarm.
Gasalier.
Gas-bracket.
Gas-burner.
Gas-lighter.
Gas-lighting by electricity.
Gas-torch.
Girandole.
Head-light.
Holophotal light.
Hydrocarbon-burner.
Hydrogen-lamp.
Hydrostatic lamp.
Illuminating-clocks.
Illuminator.
Insect-trap lantern.
Intermittent light.
Lamp.
Lamp-burner.
Lamp-chimney.
Lamp-chimney adjuster.
Lamp-cone.
Lamp-elevator.
Lamp-hanger.
Lamp-post.
Lamp-shade.
Lamp-tongs.
Lamp-wick.
Lantern.
Leading-light.
Light.
Light-ball.
Light-barrel.
Lighter. Gas
Lighthouse.
Lighting-devices.
Lighting gas by electricity.
Light-room.
Light-ship.
Lime-light.
Link.
Lucifer.
Lucimeter.
Luster.
Magnesium-lamp.
Magnesium-light.
Match.
Match-box.
Match-boxing machine.
Match-safe.
Mechanical lamp.
Night-light.
Nursing-lamp.
Oxycalcium-light.
Oxyhydrogen-light.
Parachute-light.
Petroleum-burner.
Petroleum-lamp.
Photics.
Photometer.
Promethean.
Pump-lamp.
Pyrophorus.

Pyrotechnics.
Reflector.
Revolving-light.
Rush-light.
Safety-lamp.
Sconce.
Shade-lamp.
Signal-lamp.
Sinumbra-lamp.
Skylight.
Snuffers.
Solar-lamp.
Submarine lamp.
Tar-lamp.
Torch.
Vapor-burner.
Vault-light.
Voltaic light.
Wick.
Wick-trimmer.
Zirconia-light.

Light-ball. (*Ordnance.*) The ordinary light-ball, which has been in military use for centuries, consists of a canvas sack of elongated shape, filled with a combustible and illuminating composition. It is used for lighting up works in sieges, and also for discovering the position of an enemy; in the latter case it is charged with a shell to prevent its being approached, and is fired from a piece of ordnance. As from its position on the ground it can illuminate but a limited area, parachute light-balls have been proposed. That of Sir William Congreve was to be attached to a rocket. General Boxer's light-ball was adopted into the British service in 1850. It consists of a mass of sulphur, saltpeter, and red orpiment, inclosed in a hemispherical case of tinned iron, which is attached by chains and cords to a large calico parachute that is compressed into a similar hemispherical casing, the two forming a sphere, having an annular depression surrounding it. A second tinned-iron case fits over the first, and has a fuse communicating with a train of quickmatch in the annular groove before mentioned, and also with the bursting charge. This projectile is fired from a mortar.

Light-bar'rel. An empty barrel, pierced with holes and filled with tarred shavings, to light up a breach.

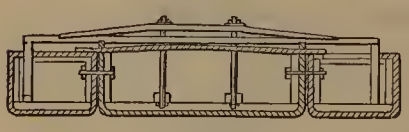
Light-boat. A vessel carrying a warning light. See LIGHT-SHIP.

Light'en-ing. The peculiar brightness of silver at the moment when the maximum of purity is attained.

"The moment when the oxidation of the lead ceases, and when consequently the cupellation is finished, is marked by a peculiar appearance called lightening. During the whole period of oxidation, the metallic bath appears more brilliant than the walls of the furnace. Its temperature is in fact higher; for not only does it share in the heat of the furnace, but its temperature is also raised by the heat disengaged by the chemical combination of the lead with the oxygen. When, however, the lead is completely oxidized, the second source of heat no longer exists; the disk of metallic silver soon sinks down to the temperature of the furnace, and, instead of being as brilliant as before, it becomes dull. On the other hand, at the moment when the last traces of lead oxidize, there is on the surface of the metallic bath only a thin pellicle of fused litharge; this quickly becomes thinner and thinner, and presents in rapid succession the colors of thin plates or of the soap-bubble, then becomes torn up like a veil, and discloses the surface of the silver beneath." — REGNAULT.

This development of purity and capacity for perfect reflection in the silver from which all dross has been removed, is a favorite simile in the Bible, where the "refiner and purifier of silver" is represented as "sitting" watching the process, whose success is evidenced by the perfect reflection of the Master's face. Fulguration.

Fig. 2945.



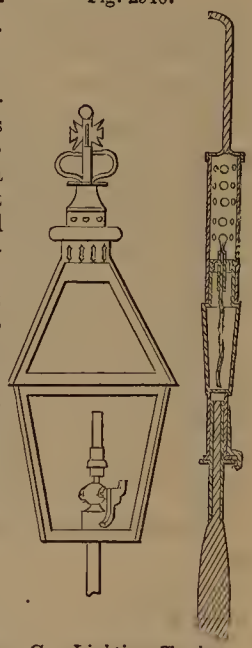
Lighter.

Light'er. 1. (*Vessel.*) *a.* A barge for transporting merchandise and stores, on rivers and canals, over bars, and to and from vessels moored in a stream, or where they cannot be laden from or discharged on to a wharf or pier alongside.

b. A craft for taking a part of the burden of a vessel to assist it over shoal places. In the example, the lighters are attached to the boat's sides by transverse braced beams and bolts, extending through the sides, and act as *camels.*

2. A torch or electrophorus for lighting gas. An *allumette* for lighting lamps or candles. The example is a torch for street-lamps. The lamp-frame has a small trap-door at the bottom, through which the hook is introduced to turn the cock by its bell-crank lever. The torch lamp is protected by a cylinder, whose perforations are large enough to allow passage of inflamed gas.

Fig. 2946.



Gas-Lighting Torch.

Light'er-screw. (*Milling.*) A screw for adjusting the relative distances of the *runner* and *bed-stone.* The *runner* rests on a *spindle*, which is supported on a *bridge-tree;* the *lighter-screw* raises and lowers the latter. See GRINDING-MILL.

Light'house. The ancient word *Pharos*, a lighthouse, is probably derived from *Phrah*, the Egyptian god personating the sun.

Pthah, in the Egyptian mythology, was the embodiment of stability. The essential portion of the figure strikingly resembles the figure of the Eddystone lighthouse, which Smeaton derived from the observation of the trunk of a tree. The figure (*a*, Fig. 2947) is shown divested of the arms and headdress of the god whom it shrouds.

The most celebrated lighthouse of antiquity is that erected on the island of Pharos, harbor of Alexandria. It was built by the orders of Ptolemy Soter, by the architect Sostratus, and finished under Ptolemy Philadelphus, 280 B. C. The wonderful energy of Alexander's mind seems to have comprehended all at a glance. He visited the little town of Rhacotis, saw his superb city as by a dream of enchantment, his Macedonian mantle covering the ground between the river and Lake Mareotis. He gave his orders to Dinocrates, the architect of the temple of Diana at Ephesus, settled the main details of the plan, and never saw the place again.

The Pharos was 450 feet high, and the light was visible at a distance of 42 miles (300 stadia, *Josephus*). It was built of white marble, and cost 800 talents, $825,500, if the talents were Attic. It was formed in several stories, decreasing in dimensions towards the top, where fires were lighted in cressets. The ground-plan was hexagonal, the sides alternately concave and convex; each a stadium in length; the 2d and 3d stories were of the same form; the 4th was square, with a round tower at each angle; the 5th circular, continued to the top, to which a winding staircase conducted. The whole was surrounded by a sea-wall, and was on the right hand of the harbor-entrance, opposite the promontory of Lochias, on which was the royal palace.

Fires were kept lighted on the summit, and it was inscribed, "King Ptolemy to the gods, the saviors, for the benefit of sailors." Sostratus carved his own name beneath and filled it with mortar, upon which Ptolemy's name was inscribed. In process of time the mortar scaled off and brought the name of the architect to the surface. The tower fell A. D. 1303.

Other ancient lighthouses were situated at Messina, Ostea, Ravenna, Puteoli, Caprea, Rhodes, Dover, the Thracian Bosphorus. The light in each was obtained by fires.

During the Saxon rule in England, beacons were erected to direct navigation, and persons were appointed to keep them in order. The expense was defrayed by the county. Pitch boxes were made use of in the reign of Edward III.

The Eddystone lighthouse (*b*) is erected upon a rock of that name ten miles from shore, off Plymouth, England. A lighthouse was built on the spot, 1696–99, by Winstanley, who perished with it in a storm, November 27, 1703. Rebuilt of wood in a different form by Rudyard, 1706, and burnt 1755. Rebuilt by Smeaton of dovetailed and metal-bound granite blocks, 1757.

Fig. 2947.

Lighthouses.

a, the Egyptian *Pthah*. *c*, the Bell Rock Lighthouse.
b, the Eddystone Lighthouse. *d*, the Skerryvore Lighthouse.

The surface of the rock was irregular and inclined. It was cut into steps, the risers of which were notched so as to form dovetailed mortises for the similarly shaped blocks of the stones in the course which interlocked with it. Each block had a level bearing, and the outside pieces were guarded by a border of rock which rose around them. The stones in a course were dovetailed together and additionally secured by cramps. The respective courses were secured to those above and below by dowel-pins consisting of tree-nails.

Six courses (8 ft. 4 in.) brought the structure to a level surface, eight other courses are solid, and from this point the structure is made hollow. The hight of the tower and lantern is 85 feet 7 inches. It was built in 421 working-days, being finished October 16, 1757.

The light was originally a chandelier with twenty-four candles. It is now a catoptric light, — an Argand lamp and parabolic reflectors. The change was made in 1807.

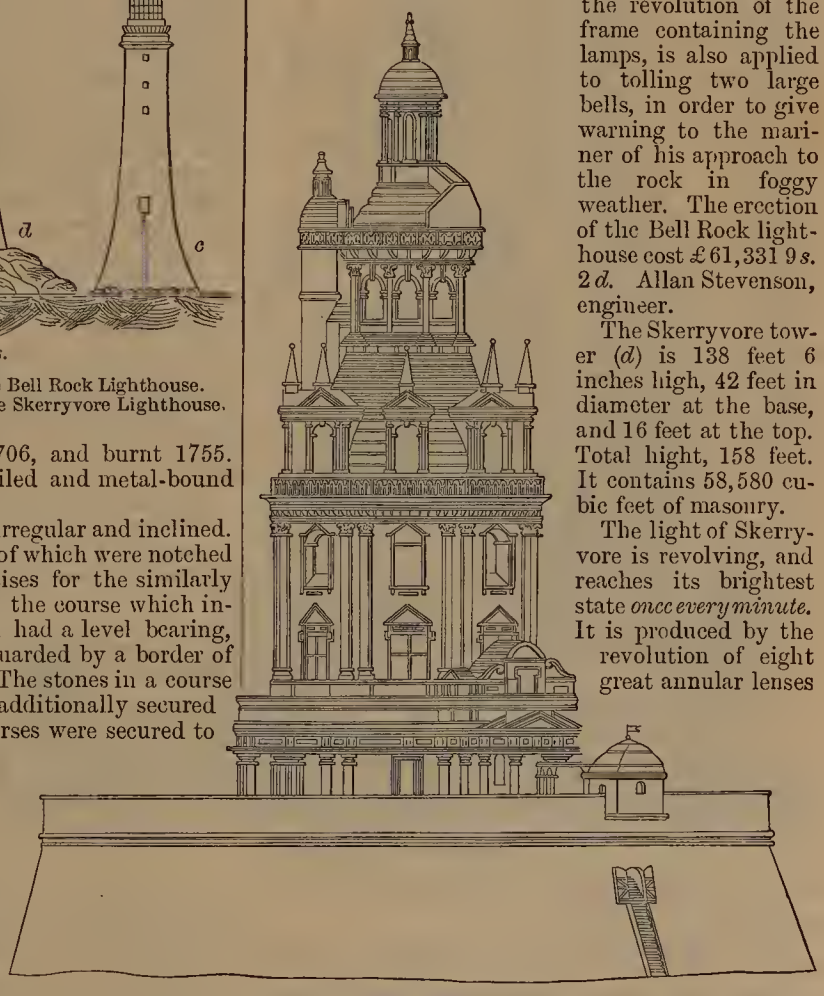
The Bell Rock lighthouse (*c*), on the rock once called the Inch-Cape and celebrated in a ditty by Southey, was erected 1807–10. The rock is off the Frith of Forth, and is 230 × 427 feet, eleven miles from land. The surface is bare at low water. The lighthouse is built in the manner of the Eddystone, the stones being joggled together, and the layers doweled together by tree-nails. Holes were bored in a circle of 36 feet diameter, and pieces of timber 50 feet in length inserted to support a temporary shelter for 30 workmen during the summer months. The structure is 42 feet diameter at the base, 13 feet at the top. The lower solid portion is 30 feet; total hight, 115. The door is 30 feet from the base.

The lantern is 12 feet in diameter, 15 feet high, has a balcony around it, is framed of cast-iron, and has plate-glass sides, the panes being 27 × 30 inches.

The light is a catoptric, the parabolic reflectors being 24 inches across. It is visible 18 or 20 miles distant.

The light is a *revolving red and white light*, and is produced by the revolution of a frame containing sixteen Argand lamps placed in the foci of paraboloidal mirrors, arranged on a quadrangular frame, whose alternate faces have shades of red glass placed before the reflectors, so that a red and a white light are shown successively. The machinery, which causes the revolution of the frame containing the lamps, is also applied to tolling two large bells, in order to give warning to the mariner of his approach to the rock in foggy weather. The erection of the Bell Rock lighthouse cost £61,331 9*s.* 2*d.* Allan Stevenson, engineer.

Fig. 2948.



Tour de Corduan (*Elevation*).

The Skerryvore tower (*d*) is 138 feet 6 inches high, 42 feet in diameter at the base, and 16 feet at the top. Total hight, 158 feet. It contains 58,580 cubic feet of masonry.

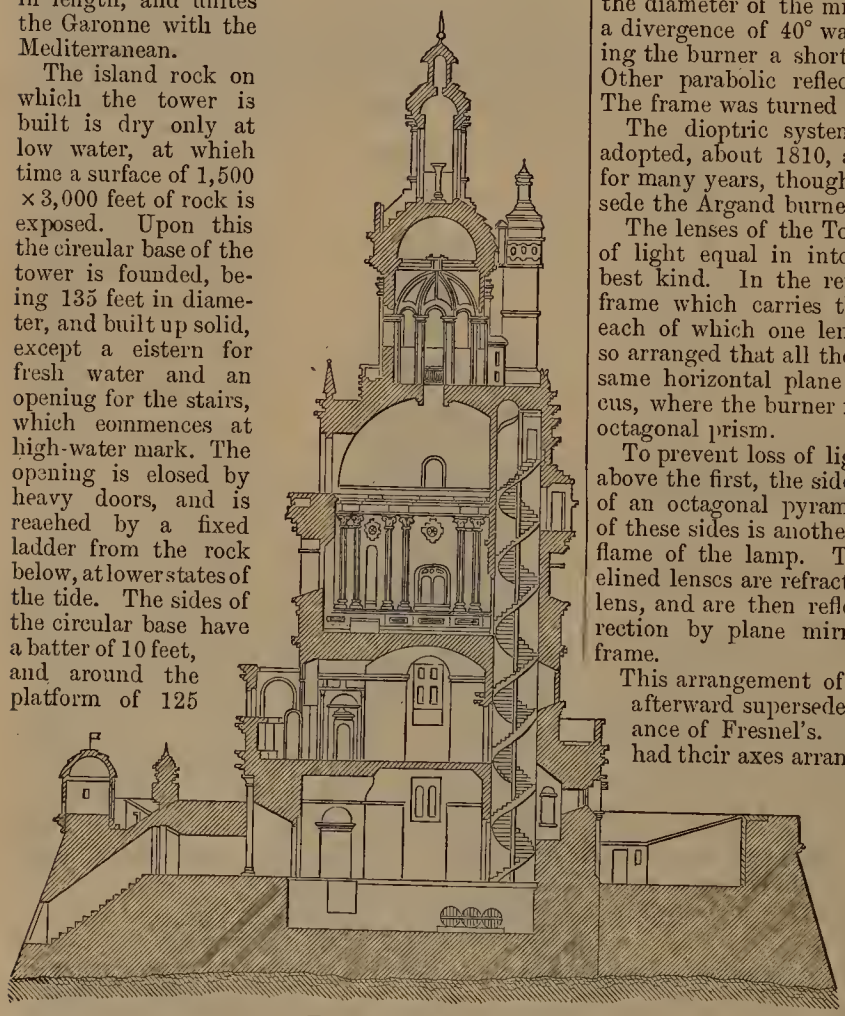
The light of Skerryvore is revolving, and reaches its brightest state *once every minute*. It is produced by the revolution of eight great annular lenses around a central lamp with four wicks, and belongs to the first order of dioptric lights in the system of

Fresnel. It may be seen from a vessel's deck at the distance of eighteen miles. The entire cost of the lighthouse, including the purchase of the steam-vessel, and the building of the harbor at Hynish for the reception of the small vessel which now attends the lighthouse, was £86,977 17 *s.* 7 *d.*

The Tour de Corduan is the most magnificent lighthouse of modern times. It is situated on a rock at the mouth of the Gironde, one of the most important rivers of France. This tower is 182½ English feet in hight, and is built in the Ornante Renaissance style of the period. It was commenced under the reign of Henry II., in 1584, and finished in that of Henry IV., in 1610. The architect was Louis Le Foix.

The commercial city of Bordeaux is situated upon the river 70 miles from its mouth, and at the time the lighthouse was built it had another special value, as it was a part of the projected chain of water-courses connecting the Bay of Biscay with the Mediterranean. This was effected shortly afterward by the canal of Languedoc, which is 150 miles in length, and unites the Garonne with the Mediterranean.

Fig. 2949.



Tour de Corduan (Section).

The island rock on which the tower is built is dry only at low water, at which time a surface of 1,500 × 3,000 feet of rock is exposed. Upon this the circular base of the tower is founded, being 135 feet in diameter, and built up solid, except a cistern for fresh water and an opening for the stairs, which commences at high-water mark. The opening is closed by heavy doors, and is reached by a fixed ladder from the rock below, at lower states of the tide. The sides of the circular base have a batter of 10 feet, and around the platform of 125 feet diameter thus made, is a wall 12 feet thick at its base and 12 feet high.

On the central circular area of 100 feet diameter is erected the tower, which has 50 feet diameter at the base, and has several stories diminishing towards the summit. The lower story is Doric, the 2d and 3d Ionic, the 4th Corinthian, the 5th Composite. The interior was handsomely decorated and furnished; the apartments of the 1st and 2d stories being finished for domestic use, store-rooms, etc.: the 3d was a handsome circular chapel, 31 feet in diameter, and having a dome 40 feet high. Upon this was erected the Corinthian cupola 27 feet high, which was 21 feet in diameter, had a stone balustrade around it, and supported the lantern, which formed the summit and was 5 feet internal diameter, 9 feet externally, and 17 feet high.

When this tower was erected the light was made by blazing wood, which was burnt in the lantern in a cresset. Coal was afterwards substituted. The smoke rose through an opening 18 inches in diameter in the dome of the lantern, passed into a finial chamber above, and escaped by side openings.

In 1727, the lantern was destroyed, and an iron one substituted by M. Betri.

In 1780, the catoptric system of lighting was introduced by Borda, an Argand burner being placed in the focus of a parabolic mirror formed of copper plated with silver. The focal length was about 4 inches, the diameter of the outer edge 21 inches. The beam of projected light was a cylinder equal to the diameter of the mirror. This being too partial, a divergence of 40° was given to the rays by removing the burner a short distance from the true focus. Other parabolic reflectors were afterwards added. The frame was turned to make the light revolve.

The dioptric system of Fresnel was eventually adopted, about 1810, and is likely to remain intact for many years, though the electric light may supersede the Argand burner which he used.

The lenses of the Tour de Corduan project a cone of light equal in intensity to eight mirrors of the best kind. In the revolving dioptric system, the frame which carries the lenses has eight sides, to each of which one lens is attached. The whole is so arranged that all the axes of the lenses are in the same horizontal plane and meet in the common focus, where the burner is situated, forming one large octagonal prism.

To prevent loss of light, a second frame is placed above the first, the sides of which form the frustum of an octagonal pyramid, and incline 50°; on each of these sides is another lens, having its focus in the flame of the lamp. The rays which fall on the inclined lenses are refracted parallel to the axis of the lens, and are then reflected into the horizontal direction by plane mirrors placed above the upper frame.

This arrangement of upper lenses and mirror was afterward superseded by another elegant contrivance of Fresnel's. A series of triangular prisms had their axes arranged in horizontal planes, and so adjusted that the light falling on the face next the flame was thrown upon the back of the prism, where it was totally reflected; and by a second refraction at the third side of the prism, it obtained its horizontal direction.

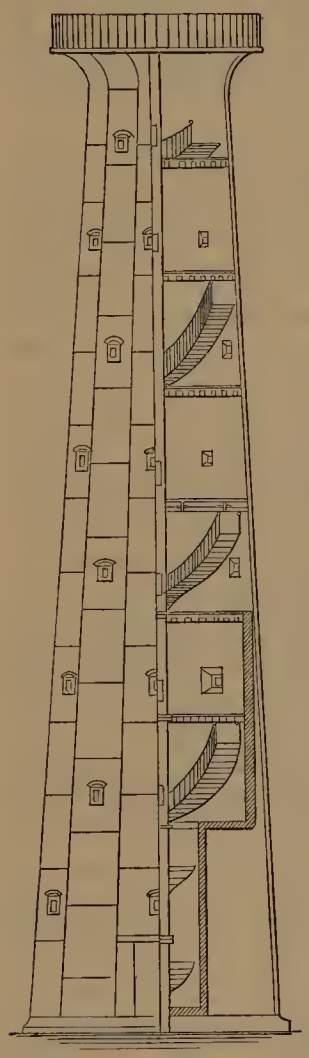
For fixed dioptric lights, the lenses are combined into a cylinder which makes an equal dispersion at all points of the horizon. The refracting apparatus of numerous lenses arranged polygonally has given way to the cylindrical lens. See Dioptric System of Lighting.

Fresnel's adaptation of the Argand lamp consists of four concentric burners protected from excessive heat by a superabundant supply of oil which is pumped into the wick-tubes, and constantly overflows.

The oil of colza (*Brassica campestris*) is used, and abundant ventilation is afforded by a lofty chimney.

The first screw-pile lighthouse actually erected prior to February, 1841, was at Port Fleetwood, near Lancaster, England. The screws which entered the bed of the river supported piles having screws at their upper ends, to which the timber columns supporting the frame of the superstructure were secured. These were united together by diagonal braces extending from the foot of one to the top of another. The first cast-iron lighthouse was put up at Point Morant, Jamaica, in 1842. The tower is formed of 9 tiers of plates, 10 feet high and ¾ inch thick, united to each other by bolts and flanges on the inside. The plates of each tier have a common radius. It was filled in with masonry and concrete to the hight of 27 feet, and rested on a granite foundation.

Fig. 2950.



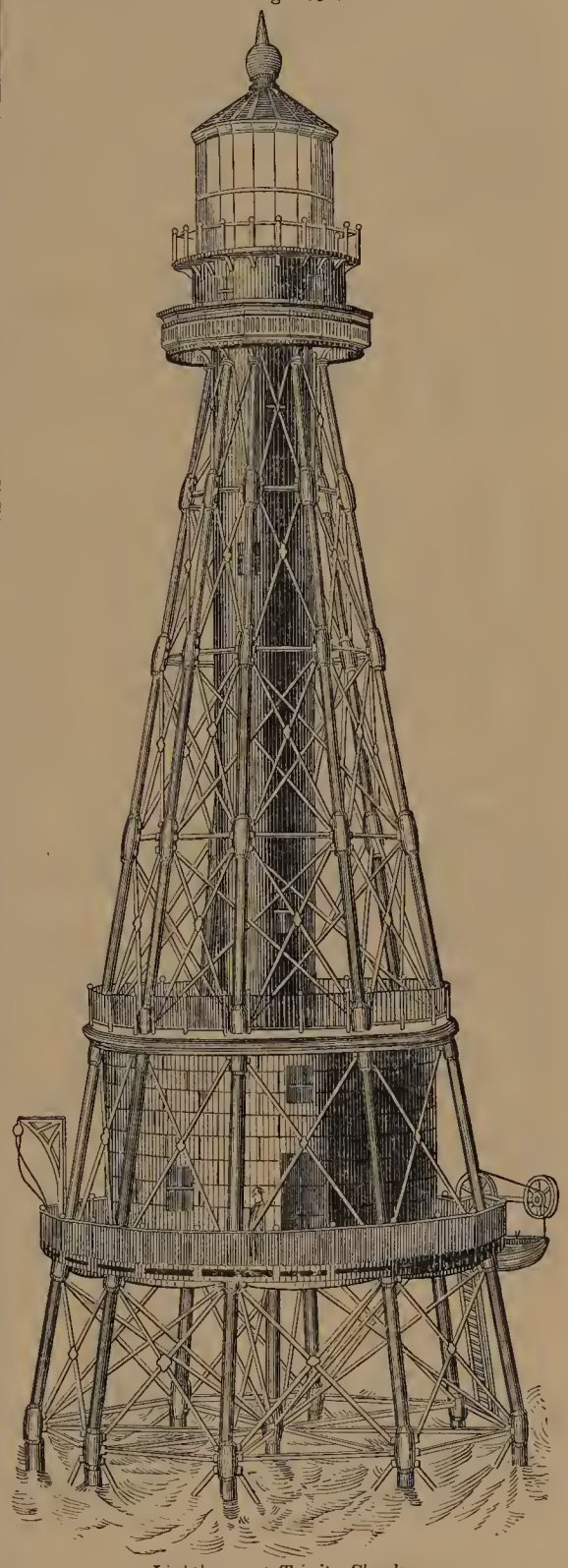
Iron Lighthouse, Bermuda.

Its total hight was 96 feet, the upper and lower diameters being respectively 18 feet 6 inches and 11 feet.

Fig. 2950 is a cast-iron lighthouse on a plan similar to the foregoing, subsequently erected at Bermuda. It is 105 feet 9 inches in hight, the lower diameter being 24 feet in addition to the flanges by which the plates of each tier are secured to each other, and those which united the successive tiers. They are strengthened by angular feathers ½ inch thick.

Fig. 2951 represents one of two similar lighthouses erected by the United States government at Trinity Shoals and Timbalier, in the Gulf of Mexico. It is supported upon 9 screw-piles, — a central one surrounded by 8 others at distances of somewhat less than 15 feet 4 inches, — each being 20 feet distant from the central one, and secured together at the ground by adjustable wrought-iron links, and above by diagonal braces, and by radial struts to the central pile. The summit of each pile is encased in a cast-iron socket for receiving the column and the radial and diagonal braces. The jointed columns which support the lantern have a similar provision for their diagonal braces, the arrangement of which will be understood from the illustration. The different series of columns are joined together by sleeves. The first series above the foundation is 20 feet long, the second 15 feet, the next two 18 feet, the fourth, fifth, and sixth being respectively 15 feet 6 inches, 14 feet, and 12 feet 6 inches. The columns of the first series are of wrought-iron, forged tapering; those above are of hollow cast-iron, each series successively decreasing in diameter. The lantern is supported on a cylinder of boiler-iron resting on a platform at the top of the columns.

Fig. 2951.



Lighthouse at Trinity Shoals.

The following is a list of the electric lights in England and France, with the dates at which they were erected: Dungeness, January, 1862; Cape La Heve, France, South Light, December, 1863, North

Light, November, 1866; Cape Grisnez, France, February, 1869; Souter Point, England, January, 1871; South Foreland, England, with two lights, January, 1872, in the first place in 1858–60 by Professor Holmes, and afterward England took the lead in this matter of the adaptation of electric illumination to lighthouse purposes. The Bishop rock light, Scilly Islands, the old Cassiterides of Herodotus, 145 feet high, cost £36,559. In the British Isles there are 357 shore lights and 47 floating lights. The French have 224 shore lights. The average annual expense in England of a shore light is £500; of a floating light, £1,200.

The lighthouses of the world are estimated at 2,814.

Table of the Visible Distance of Objects in Geographical or Nautical Miles.

Hight in Feet.	Distance in Miles.	Hight in Feet.	Distance in Miles.	Hight in Feet.	Distance in Miles.	Hight in Feet.	Distance in Miles.
* .663	1	11	4.08	30	6.74	150	15.07
1	1.23	12	4.26	35	7.28	200	17.4
2	1.74	13	4.43	40	7.78	300	21.32
3	2.13	14	4.6	45	8.25	400	24.64
4	2.46	15	4.77	50	8.7	500	27.52
5	2.75	16	4.92	55	9.13	1,000	38.92
6	3.01	17	5.07	60	9.53	2,000	55.04
7	3.25	18	5.22	70	10.29	3,000	67.41
8	3.48	19	5.36	80	11.01	4,000	77.84
9	3.69	20	5.5	90	11.68	5,000	87.03
10	3.89	25	6.15	100	12.31	1 mile.	89.43

* For a geographical or nautical mile, the curvature equals 7.962 inches.

Light'ing. (*Metallurgy.*) Heating metal and allowing it to cool gradually. *Annealing.* The term is especially applied to the heating after hammering or rolling, to restore ductility.

Light'ing-de-vi'ces. 1. Two pieces of wood may be rubbed together so as to char the frictional surfaces and eventually produce flame. This may be assisted by tinder, punk, etc., which readily take fire.

2. Iron may be hammered till it acquires a red heat, and is capable of firing combustible matters.

3. Steel struck by a flint yields sparks, which, falling upon charred linen, cause it to burn sufficiently to inflame sulphur.

This device amplified gave rise to the *miner's steel mill.*

4. The *miner's steel mill,* as it is called, has a steel wheel rapidly revolved by gearing and hand-

Fig 2952.

Steel-Mill and Döbereiner's Lamp.

crank, its periphery being in contact with a flint fixed to a holder on the frame. It was operated by a child, who waited upon the miner and lighted him at his work.

It was superseded by the safety-lamp of Sir Humphry Davy. See SAFETY-LAMP.

5. Alum, sugar, and flour, when mixed and calcined, have a tendency to take fire when exposed to the atmosphere. Hence *Homberg's pyrophorus.* See PYROPHORUS.

6. Chlorate of potash mixed with sugar kindles into flame on the contact of sulphuric acid. The matches were dipped successively in melted sulphur and then in chlorate of potash, and were ignited by pressing the prepared ends upon a sponge of asbestus saturated with sulphuric acid and placed in a bottle. This was the *Promethean.*

7. Phosphorus, placed between the folds of a piece of paper and rubbed to and fro, will heat sufficiently to kindle a sulphur match. Hence the *phosphorus light* in use in 1675.

8. The *phosphoric tapers* were of wax, having wicks coated with phosphorus. They were inclosed in glass tubes hermetically sealed. They were ignited by cutting off the end of the tube with a file, when the phosphorus became ignited by the action of the air.

9. The *phosphorus bottle* was a small vial, into which a piece of phosphorus was placed and stirred around with a hot wire. The phosphorus being partially burnt emitted fumes which coated the inside of the vial with oxide of phosphorus. The vial was then tightly corked. In use, a match dipped in sulphur was dipped into the phosphorus, and flame resulted from the energetic action of the two.

To expedite the flame, the match, after dipping, was rubbed on the cork or a piece of wood.

10. When chromic acid is brought in contact with alcohol it parts with its oxygen so rapidly as to cause ignition. Mix gently in a mortar a small portion of chromic acid and one fourth the quantity of powdered camphor; a few drops of alcohol dropped upon it from considerable hight will cause ignition and deflagration.

11. Phosphorus and chlorate of potash rubbed together in a mortar will explode.

12. Potassium has such energetic affinity for oxygen as to decompose water when brought into contact therewith; the oxygen combines with the metal to form potash, and the hydrogen is ignited. A parallel effect takes place in regard to sodium when the water is previously heated.

13. Ammonia added to a solution of chloride of gold produces a yellowish-brown precipitate (*aurate of ammonia*), fulminate of gold. This explodes by friction. See FULMINATE.

14. Volta's *inflammable air-lamp* was a glass reservoir charged with hydrogen gas, which could be expelled in a jet as required. Upon the pedestal was an *electrophorus,* by which a spark could be emitted in the path of the jet which was lighted thereby. This was the precursor of the *hydrogen-lamp* and of a whole train of ingenious devices, the culmination of which is found in apparatus for lighting gas by electricity, erected on a large scale in the Capitol of the United States. See LIGHTING GAS BY ELECTRICITY.

15. Döbereiner's inflammable lamp (Fig. 2952) has a flask attached to a plate and stop-cock, and suspended in a receiver containing sulphuric acid and water. A piece of zinc is suspended in the inner vessel in contact with the acid, and the evolution of gas in the upper part of the flask forces the dilute acid out at bottom into the surrounding receiver, and stops the evolution of gas. When the stop-cock is turned, a jet of gas issues and impinges upon a piece of spongy platinum, which becomes red-hot and ignites the jet. The escape of gas allows the acid to rise in the flask, and the evolution of gas is resumed.

16. In the line of the voltaic phenomena must next be cited the heating of a platinum wire by an electric current derived from a pair of voltaic plates in an acid bath. Touchwood, a match, or a jet of gas in contact with the incandescent wire become inflamed. This device and the electric spark produced at the interval of a broken circuit are the means for lighting gas by electricity.

17. Air compressed to a sufficient extent in a tube in which is a piece of German tinder becomes heated so as to kindle the tinder, which will then ignite a brimstone match. This was called the *pneumatic tinder-box* or *light-syringe.*

18. The *oxymuriate matches* were founded upon the action of a compound of chlorate of potash and sugar when exposed to sulphuric acid.

These substances made into a paste with gum and colored by vermilion were used to tip splints. These were dipped in sulphuric acid to inflame them. To these succeeded the *lucifer-match.*

19. The *lucifer-matches* were originally tipped with a paste of chlorate of potash, sulphuret of antimony, and starch, and were drawn between two sand-paper surfaces. This was the inauguration of the friction-match, and the ignition produced a detonation.

20. The *Congreve match* substituted phosphorus for sulphide of antimony, and the match ignited on any rough surface. The substitution of saltpeter for chlorate of potash produced quiet ignition. Introduced in 1834.

Then followed the substitution of saltpeter for chlorate of potash, so that both the original articles were superseded, greater safety and comfort being attained.

The chemical reactions are as follows: —

The phosphorus is ignited by frictional compression.

The heat evolved decomposes the saltpeter.

The evolution of oxygen supports the flame and enables the ignition of the sulphur.

The burning sulphur ignites the wood.

Stearine was then substituted for the sulphur, into which the match was dipped before tipping with the more inflammable compound.

Light'ing Gas by E-lec-tric'i-ty. A means of lighting gas by developing a spark or producing a red heat in a platinum coil at the jet of issuing gas.

It is used in situations difficult of access, such as the rotunda, dome, and tholus of the Capitol at Washington, and the Senate and House of Representatives, whose gas-burners are above the glass ceilings in a chamber below the roof. Gardiner's apparatus, used in the dome and tholus, was the subject of a report by a commission consisting of Messrs. Shaffner, Pike, and Knight.

From the report the following is extracted: —

"The gas-pipe connections consist of circles of burners at 45, 80, and 165 feet from the floor of the rotunda, and are furnished with 300, 325, and 425 burners respectively. In addition to these, a cluster of 90 burners is placed in the tholus at a hight of 264 feet from the floor, and, being 60 feet above the crown of the dome, is, of course, invisible from the interior, but is a beautiful object viewed from the Capitol grounds, and visible at a distance of many miles.

"The flow of gas at each tier, and in the tholus, is equalized by a regulator, and governed by a stop-cock, the latter being opened and closed by electro-magnetic engines in their immediate vicinity, worked from the battery, the central brain of the apparatus from which ramifies the nervous fluid which vitalizes the motive agents and the illuminating coil of each of the 1,130 burners.

"The battery occupies an elliptical room 45 by 36 feet, and consists of 200 glass jars of a depth and diameter of about 13 inches, containing two zinc plates 9 by 10 inches, weighing 6 pounds each, and an interposed carbon plate, all supported by suitable insulators in the acid bath. It is disposed on benches in concentric series in the room, and arranged in sections of 20 jars each, to be brought into service as required.

"The connections consist of five miles of No. 10 copper wire, doubly wrapped with linen yarn, and, when necessary, incased in india-rubber tubing: this is securely laid in protecting pipes or through passages drilled through the walls, the return circuit from the engines and the burners being made through the gas-pipes.

"The burners used have an indestructible lava tip, which acts as an insulator, and each is provided with an insulated coil of platinum wire, placed on one side of the orifice, so as not to interfere with the free exit of the gas, which is lighted by exposure to the red-hot metal when the electric connection is made.

"The tiers of burners are divided into sections of from 30 to 50 burners, each section having independent connection with the instrument, so that a tier being divided into ten sections, it is lighted by a corresponding number of pulsations following the flow of the gas, which is turned on by the electro-magnetic engine belonging to and in the vicinity of the tier. The manipulation which, by successive pulsations, operates the engines, makes the series of illuminating connections, and registers the work, is performed in a passageway leading north from the floor of the rotunda, and perhaps 50 feet from the battery.

"The electro-magnetic engines consist of a double helix, with a sliding armature, on which is a latch which operates a ratchet-wheel on the axis of the stop-cock. The operator, by a succession of electric connections, works the armature piston, and turns the plug of the stop-cock such a fraction of a revolution as is represented by a number of teeth on the ratchet-wheel.

"The dial-plate has eleven keys, with a corresponding number of verniers.

"The primary electric connection with the battery is made by a stud in the central key, which, by rotation, is made to bring such a portion of the battery into play as may be required, a vernier indicating the extent of battery connection which takes place in successive sections of 20 jars.

"The surrounding keys, ten in number, are equally divided between the duties of turning on the gas and lighting the same at the five levels for which the dial-plate and keys are adapted. But four of these are yet arranged, consisting of the tiers at the elevation of 45, 80, and 165 feet, respectively, and the tholus at 264 feet.

"The fifth may be used for a tier at the spring of the dome, or a circle to illuminate the pictures.

"Each gas-key has a dark and a light segment on its disk, which are exhibited at an opening in the dial-plate, in correspondence with the closed and open position of the stop-cock, which governs the flow of gas at the tier represented by the said key.

"Each lighting key has a pointer, which indicates on its vernier the extent to which the electric connection has been made in the sections of the tier to which it belongs."

Another form of apparatus consists of a galvanic battery, Ruhmkorff's induction coil, and conducting wires, which are broken near the gas-jets so that an electric spark is produced by a charge of electricity leaping to the "tips" of the burners, each

burner being insulated, and forming a part of the circuit. The ends of the wires from which the spark proceeds are covered with platinum to prevent their corrosion.

One or the other plan is adopted in many public buildings, theaters, halls, and large stores, and it is proposed to light the street-lamps of cities by this means. A large circuit of lamps, embracing the streets of a ward or district, are connected by insulated wires proceeding from a conveniently situated battery, either magno-electric or voltaic. See also ELECTROPHORUS.

Light'ning-ar-rest'er. A device used in telegraphy for guarding against passage of atmospheric electricity through the instruments.

The line wires are attached to a plate of brass, usually serrated on the under side. This plate rests upon another plate connected with the ground, the two plates being separated by a thin layer of insulating material.

As lightning possesses enormous tension, preferring a short route even through a poor conductor to a longer one through a good conductor, it forces its passage through the layer of insulating material and thence to the ground, or *viee versa.* See LIGHTNING-DISCHARGER.

The Stoics distinguished two things in thunder, the lightning and the noise. They looked upon the first as the effect of the latter, which was properly what they termed thunder; for, according to them, thunder was occasioned by the shock of clouds, and lightning was the combustion of the volatile parts of the cloud, set on fire by the shock. Chrysippus taught that "these effects were coincident, and that our perception of the lightning before the thunder-clap is owing to our sight being quicker than our hearing."

Light'ning-con-duct'or. A metallic conductor intended to establish a definite line of least resistance between two bodies in opposite electrical states. The resistance of the line should be so small that no destructive effect shall arise from any discharge along it. Lightning-rods are included under this general definition.

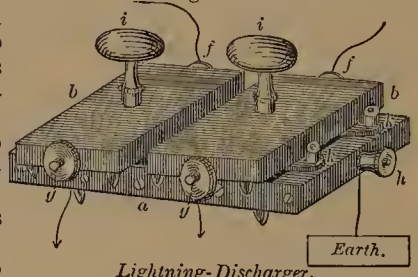
"The most important ancient notice of the relations between lightning and conducting metals appears to be that of Ctesias. He had possessed two iron swords, presents from the King Artaxerxes Mnemon and from his mother Parysatis, which, when planted in the earth, averted clouds, hail, and strokes of lightning. He had himself seen the operation, for the king had twice tried the experiment before his eyes. The exact attention paid by the Etruscans to the meteorological processes of the atmosphere in all that deviated from the ordinary course of phenomena makes it certainly to be lamented that nothing has come down to us from their Fulgural books. The epochs of the appearance of great comets, of the fall of meteoric stones, and of showers of falling stars, would no doubt have been found recorded in them, as in the more ancient Chinese annals, of which Edouard Biot has made use. Creuser has attempted to show that the natural features of Etruria may have influenced the peculiar turn of mind of its inhabitants. A 'calling forth' of the lightning, which is ascribed to Prometheus, reminds us of the pretended 'drawing down' of lightning by the Fulguratores. This operation consisted in a mere conjuration, and may have been of no more efficacy than the skinned ass's head, which, in the Etruscan rites, was considered a preservative from danger in thunder-storms.

"In the very complicated Etruscan augural theory, a distinction was made between the 'soft reminding lightnings sent by Jupiter from his own perfect power, and the violent electrical explosions or chastening thunderbolts which he might only send constitutionally after consultation with the other twelve gods.'" — HUMBOLDT.

Light'ning-dis-charg'er. (*Telegraphy.*) A device to protect telegraphic apparatus from the effects of atmospheric electricity passing over the wires.

In Fig. 2953, *a* is an iron plate called the earth-plate, over, but not in immediate contact with which are two smaller plates *b b* called conductors; each plate has two screws for attaching wires. To the screws *f f* are attached the up and down wires respectively; to the screws *g g*, the wires leading to the apparatus; and to the screw *h*, the earth-wire. The upper plates *b b* are kept in place by small knobs *i i*, attached to them and by buttons *k k* on the earth-plate. In order to prevent metallic contact, these, as well as the sides of the earth-plate, are covered with vulcanite. The atmospheric electricity, on reaching the conductors, springs over to the earth-plate, and is thus diverted from the apparatus. See also PARAGRELE.

Fig 2953.



Lightning-Discharger.

Light'ning-rod. A form of lightning conductor, attached to a structure for the purpose of protecting it from lightning.

It is preferably made of copper, that metal having a greater conducting power than any other, but iron is the material usually employed.

The alleged improvements since its invention by Dr. Franklin are innumerable; most of these are, however, worthless, or of a trifling and unimportant character.

The first lightning-rod erected with a definite purpose of protection was put up by Benjamin Franklin soon after 1752, when he brought down electricity from a thunder-cloud. The first in England was set up at Payne's Hill, by Dr. Watson. In 1766 one was placed on the tower of St. Mark at Venice; it has since escaped injury, though previously it had been frequently struck by lightning.

Great opposition was at first raised against the invention, and the charges of impiety were revived; but the centuries were exploding these notions, and Franklin held his ground. After the theory was admitted, a curious war arose. *Knobs* against *points.* Benjamin Franklin said *points;* but as he was a rebel, King George III. and his admirers of course declared for *knobs.* Franklin, who could handle a pen like a cimeter, wrote: "I enter into no controversy. I leave my philosophical opinions to take their chance in the world. If they are right, truth and experience will support them; if wrong, they ought to be refuted and rejected. Disputes are apt to sour one's temper and disturb one's quiet. I have no private interest in the reception of my inventions by the world, having never made, nor proposed to make, the least profit by any of them. The king's changing his pointed conductors for blunt ones is, therefore, a matter of small importance to me. If I had a wish about it, it is that he had rejected them altogether as ineffectual. For it is only since he thought himself and family safe from the thunder of heaven that he dared to use his own thunder in destroying his innocent subjects."

The king requested the president of the Royal Society to resign, because he could not see with royal eyes. The knob theory has long since been entirely exploded.

Sir W. Snow Harris's lightning-rod for land use consists of wide bands of copper or of copper tubing, the metal of either being $\frac{1}{5}$ inch thick. The metal is prepared in lengths of 10 feet. The sections of tubing are united by intermediate screw sections. The strip conductor is nailed to the wall; the tube is secured by coupling-pieces. The upper extremity has a bayonet-point 18 inches long, $\frac{3}{4}$ inch in diameter at the point of connection to the solid plug with which the tube terminates. The ground connection consists of a descending rod and a cross rod, giving 3 divergent branches.

Harris's lightning-conductor for vessels converts the masts into lightning-conductors by the insertion in grooves of a double set of copper plates, connecting by bands of copper leading through the side under the deck-beams, and with the large bolts leading through the keel and keelson. The system is designed to include all large metallic masses in the hull.

These plates are from 1 to 4 inches wide, curved so as to correspond to the round of the mast, into which they are inlaid longitudinally. They are from $\frac{1}{16}$ to $\frac{1}{8}$ inch thick, 4 feet in length, and are secured by copper nails at intervals of 6 inches.

According to the opinion of Sir W. Snow Harris and other eminent electricians, the insulation of a metallic conductor by inclosing it in a glass tube or by glass supports is unnecessary if the continuity of a sufficient conductor be preserved. Harris states that the electrical discharge does not quit an easy line of transit such as is furnished by a copper rod of sufficient size, to pass to other bodies out of the line. He considers it unlikely that the lightning would leave such a rod even to reach metallic clamps, but it would be unwise to put such temptation in its way, unless the clamps were so connected with the ground as to make them a part of a continuous line of descent.

It is very important to make ground connections for extensive areas of iron surfaces such as are found in the rods, iron beams and joists, copings, lintels, thresholds, stairs, chimney, window, and door caps, window-casings, pillars, etc. This matter is not much attended to, however, but iron is inserted wherever convenience dictates, regardless of all electric considerations.

The conductors should be prolonged until reaching moist soil, or if this be impracticable should be carried, at a depth of two feet or more, to a distance of some 30 feet from the building, or connected with old chain conveyed to a similar distance; the trench in which it is laid being partially filled with carbonaceous matter.

In regard to the area protected by a rod, a difference of opinion exists, and the matter cannot be considered as determined. The opinion of Leroy, 1788, was that it protected a space around equal to three times the hight of the rod. The Academy of Seiences of Paris, 1823, opined that it protected a circular space whose radius is equal to the hight of the rod. This is the general opinion, but has no sufficient data for its foundation. It is, however, the basis of the American practice in putting up lightning-rods.

Professor Henry, a high authority on the subject, recommends a rod of round iron about 1 inch in diameter, terminating in a single platinum point, and secured to the building by iron eyes. Glass insulators he considers, as do other eminent electricians, of little importance. It should preferably be placed on the west side of the building in this latitude, and especially on that chimney from which a current of air ascends during the summer season, and should be connected where practicable with the water or gas pipes of the street. Where this is impracticable, connection should be made with a well always containing water, or with an iron plate buried in the ground. This rod may be put up by an ordinary blacksmith.

The lightning-rod invented by Moses G. Farmer of Boston is formed of a core of steel, which is first carefully tinned and then covered with copper, after which the compound wire is tinned, to prevent rusting.

Lightning-rods for powder-magazines were formerly erected on a mast at a short distance from the building. It is now thought advisable to attach them directly to the building in the following manner: A strip of copper is secured to the ridge of the building, at each end of which is a lightning-rod, of $\frac{1}{2}$ inch copper, projecting about 5 feet above the highest part of the building. Copper strips pass down the hips and are secured to the eave-trough, the water-pipes being connected with the underground conductor, which is divided into two branches at about 4 feet from the building. These are about $2\frac{1}{2}$ feet below the surface, and are covered with coal-ashes and earth.

It is estimated that at least 50 persons are killed annually by lightning in the United States, 69 in France, and 22 in England, but no conductor has been contrived to be carried on the person, though it has been often suggested. The risk is so small, numerically considered, that it is not probable any great proportion of the inhabitants of any country will make special provision for avoiding the danger.

Professor Arago classed several well-known sites according to the frequency of their storms, from the best information he could obtain. His list begins as follows: —

	Days of Thunder per Year.
1. Calcutta averages	60
2. Patna (India) supposed to average	53
3. Rio Janeiro averages	50.6
4. Maryland (U. S.) supposed to average	41
5. Martinique averages	39
6. Abyssinia supposed to average	38
7. Guadaloupe averages	37
8. Viviers (France) averages	24.7
9. Quebec averages	23.3
10. Buenos Ayres averages	22.5
11. Denainvilliers (France) averages	20.6

The lowest average he gives is that of Cairo in Egypt, three days of thunder per annum. That of Paris and most of the European cities is about fifteen days. He estimates the days of thunder at New York to be about the same.

Fig. 2954 exhibits some of the numerous variety of rods for which patents have been secured in the United States.

a has a series of points formed of spiral coils combined with a tubular portion, forming the tip. The conductor is a flat strip.

b, a jointed tubular conductor for vessels. It is divided at the head of the lower mast, a branch leading down the shrouds on either side to the water.

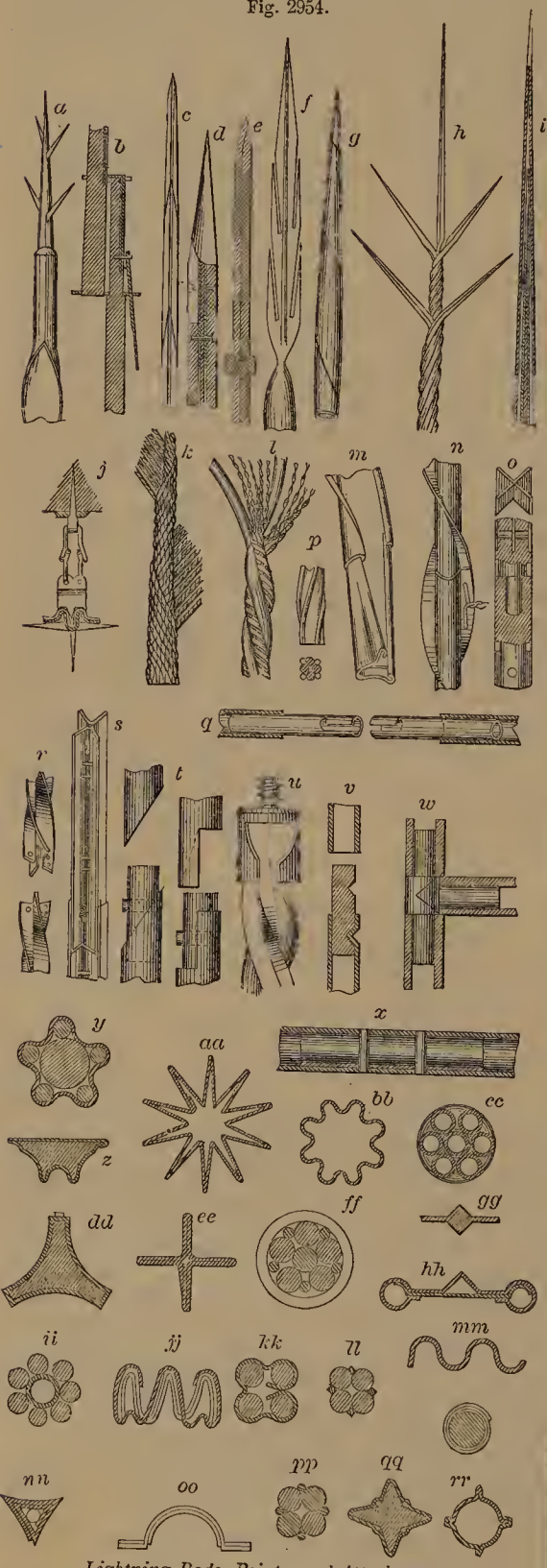
c, an iron rod tipped with copper, the point of which is gilded.

d has a central copper slip inclosed between iron side-pieces; the points of connection have interposed zinc plates.

e. The iron rod is grooved to receive a copper slip. The joints are secured by screw-threaded washers.

f. The point is formed with two opposite wings.

Fig. 2954.



Lightning Rods, Points, and Attachments.

g. The rod is composed of a single strip of copper wound spirally so as to form a tube.

h is composed of several strands of wire laid together so as to form a rope, and having several tips.

i. The point is formed of three or more metals inclosed one within the other, the most fusible outside.

j is an insulating attachment with additional conductor points at the coupling of rod-sections.

k. A copper cable, composed of a central wire rope and two exterior strands laid up in opposite directions.

l comprises two or more copper-wire ropes intertwined with an equal number of iron rods.

m. A series of metallic strips, forming a tube, are joined together.

n. A metallic strip is doubled up or corrugated, so as to form a tube with spiral flanges.

o. The joints of the rod are coupled by pieces cross-shaped in section and secured by rivets or bolts.

p has four twisted rods with wire worming.

q. The tubular sections are united by short pieces inside slotted, so as to form a species of bayonet-joint, and held by pins.

r is composed of two strips of sheet-metal, riveted together at their angles and twisted spirally.

s. The strips constituting the rod have slots through which staples are inserted to fasten them together.

t. The sections are connected by interior short pieces fastened to each by pins.

u. The exterior cable is stiffened by a spirally flanged core. The tip is fastened by a dovetailed coupling-screw.

v. The sections of the square tubular rod are secured to each other by square plugs fastened by indenting the tubes into suitable depressions formed in them, or by rivets.

w. The sections are coupled by an interior cylinder and a tapering plug projecting from each of its ends.

x. An interior tube with pins holds the ends of the tubular sections together.

y to *r r* inclusive represent sections of various kinds of patented rods.

Light-port. (*Shipbuilding.*) An opening in a ship's side provided with a glazed lid or cover. Sometimes called a *scuttle.*

Light-room. (*Nautical.*) A small chamber next to, but isolated from, the magazine. The latter receives its light through a glass partition between the two chambers.

Lights. (*Pyrotechnics.*) Pieces formed by pressing an inflammable composition, which burns with a white or colored light, into cases of large diameter or shallow vessels; such are Bengal-lights, blue-lights, etc.

Light-ship. A vessel moored in the vicinity of a dangerous shoal or headland, and carrying aloft a warning light. The first light-vessel moored on the coast of Great Britain was that at the Nore in 1734. There were, in 1850, 26 floating lights on the coast of England.

Stevenson states that the annual expense of maintaining a floating light, including the wages and victualing of the crew, who are eleven in number, is, on an average, £1,000; and the first cost of such a vessel, fitted complete with lantern and lighting apparatus, anchors, cables, etc., is nearly £5,000. The lanterns are octagonal in form, 5 feet 6 inches in diameter; and, where fixed lights are exhibited, they are fitted with eight Argand lamps, each in the focus of a parabolic reflector of twelve inches diameter; but, in the revolving lights, four lamps and reflectors only are fitted. The greatest depth of water in which any light-vessel belonging to the Corporation of Trinity House at present rides is at the

station of the *Seven Stones* between the Scilly Islands and the coast of Cornwall, and is about 40 fathoms.

Light-vessels are moored with chain-cables of 1½ inch diameter, and a single mushroom anchor of 32 cwt.; the chain-cables are 200 fathoms in length. Some of the vessels are moored to *span-ground* moorings, consisting of 100 fathoms of chain to each arm, and a mushroom anchor of similar weight at the end of each; a riding-cable of 150 fathoms is in such cases attached to the center ring of the ground-chain.

Lig'num-vi'tæ. The wood of a tree of the genus *Guiacum*, a native of the warm latitudes of America. It is hard and heavy, and is used for sheaves of ship's blocks, and for ninepin balls.

Limb. 1. The graduated arc or sector of a measuring or optical instrument.

2. (*Locksmithing.*) One of the pieces which compose a lock.

Limb, Ar-ti-fi'cial. See ARM, FOOT, HAND, LEG, ARTIFICIAL.

Lim'ber. 1. (*Gun-carriage.*) The detachable part mounted on the two fore-wheels, and to which the horses are attached. The gun is *limbered up* when the trail of the gun-carriage proper is lifted up and looped over the pintle-hook of the limber, in order for marching. See GUN-CARRIAGE.

The term *limber* is also applied to the fore-carriage of the ammunition-wagon to which the caisson or tumbril is connected.

Limbers differ in construction with the purpose and positions of the guns; as, —

The *casemate*-limber; the *field-gun* limber, with an ammunition-box; the *garrison-gun* limber; the limber with shafts; the *pole*-limber; the *siege-carriage* limber; the *battery-wagon* limber.

The parts of a limber are usually —

The axle, pole, futchels, pintle, pintle-bolster, bolster yoke-hook, bolster-plate, upper and lower pintle-plates, limber-wheel, ammunition-box, trail-ring, limber-hook, limber-chain, etc.

2. (*Shipwrighting.*) A passage on each side of the keelson for bilge-water. It is covered in by a movable board called a *limber-board*, whose edges rest respectively upon the *keelson* and *limber-strake*.

3. A shaft or thill of a vehicle.

Lim'ber-board. (*Shipbuilding.*) A plank reaching from the keelson to the limber-strake, and merely butting against the bulkheads, so as to be easily taken up to expose the *limbers*.

Lim'ber-chain. 1. (*Nautical.*) A chain passing through the *limber-holes* of a vessel by which they may be cleared of dirt that chokes them.

2. (*Artillery.*) A keep-chain which goes round the pintle and confines the trail to the limber, preventing its flying off the limber-hook.

Lim'ber-chest. The ammunition or tool chest belonging to the limber of an artillery-carriage of any description. Those of the gun-carriage and caisson are fitted up as ammunition-chests, while those of the forge and battery wagon contain respectively tools and stores for blacksmiths', and for carriage-makers' and saddlers' use.

Lim'ber-holes. (*Shipwrighting.*) Holes through the floor-timbers on each side of the keelson, to allow the passage of bilge-water. The row of holes constitutes the *limber-passage*.

Lim'ber-hook. (*Artillery.*) The hook on the limber to which the trail of the gun is attached.

Lim'ber-ing-up Hoop. (*Artillery.*) A stirrup-handle on the trail of a gun by which the piece is moved in limbering and unlimbering.

Lim'ber-strake. (*Shipbuilding.*) That strake of the inner skin which is nearest to the keelson. A space between it and the latter is called the *limber*, and forms a passage for bilge-water.

Lime. (*Sugar.*) Lime-water used in clarifying coarse sugar.

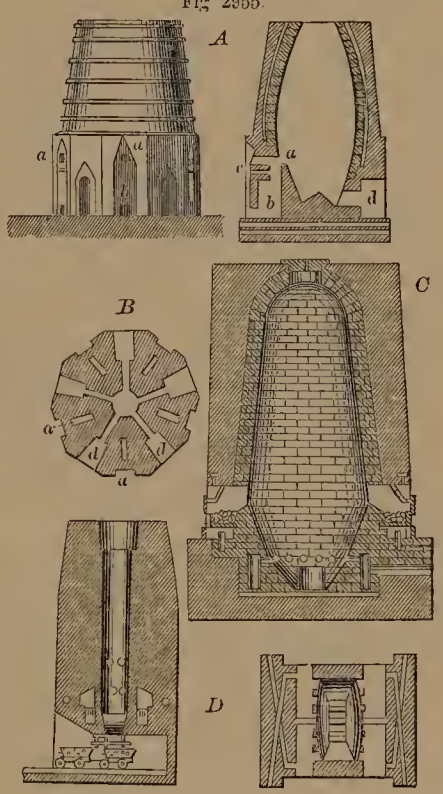
Lime-floor. A floor of lime-mortar, spread, beaten, and rubbed smooth.

Lime-kiln. Lime is derived from its carbonate, which exists in immense quantities in nature in the form of limestone, including marble. It is, where these are abundant, prepared from oyster-shells, which are also a carbonate of lime.

The process consists in calcining the carbonate in kilns, during which the carbonic acid is driven off, leaving oxide of calcium or quicklime.

The forms of kiln are various, probably the most primitive being made by excavating a hole in the earth in the shape of an inverted cone, in which alternate layers of limestone and fuel were placed, and

Fig. 2955.



Lime-Kilns.

the top covered with sods. Kilns having chambers in the form of an inverted cone are generally employed in places where materials are scarce and coal is the fuel used. The ovoidal form, truncated at its upper part, is, however, generally preferred, on account of its losing less heat by radiation, and allowing the upper portion of the lime to settle more gradually and evenly as the lower portion is withdrawn.

The kiln may be built of either stone or brick, either cylindrical or rectangular, and is usually erected against the side of a natural bank, or a mound is thrown up behind it.

A B represents a kiln used at Rudersdorf, Prussia, adapted to burn one part wood and four of turf. It has five fireplaces *a a*; *b* is an ash-pit; *c c* are openings for regulating the draft; *d*, openings for withdrawing the lime.

It is lined with a double thickness of fire-bricks, the space between which and the outer masonry is

filled in with well-rammed cinders to prevent loss of heat.

A continuous kiln, employed in Belgium, has eight openings for removing the lime, which is being continually withdrawn while fresh charges are added at the top. It is charged with alternate layers of coal and limestone, in the proportion of one coal to four limestone, and is allowed to cool but once a year, for inspection and repairs.

A kiln was invented by Count Rumford, having for its principal objects to consume the smoke, to bring a large surface of flame and hot vapor in contact with the limestone, to keep the latter separate from the fuel, and to allow the process to be continuous.

It consists of a truncated cone, some 15 feet high, 2 feet in diameter at base, and 9 inches at top. In order to retain the heat, the sides, which are of brick and very thin, are double and filled in with dry wood-ashes. The fuel is introduced through an opening above, which is covered by a hinged iron plate, raised and lowered by means of a chain, to regulate the draft. The opening for cleaning the fireplace is provided with a grate and ash-pit, and also, by causing a horizontal draft into the furnace, assists in consuming the smoke. The limestone is fed in at the top of the furnace. The products of combustion are directed downward before they are admitted into the body of the kiln, the unconsumed portion finally passing out at the top. The incandescent mass of lime below assists in heating the charge above. The lime is removed at an opening below, and fresh charges are added at the top as this is gradually withdrawn.

In the kiln *C*, blasts of air are forced through the burnt and cooling lime, and mingle with the caloric currents from the furnaces. The furnaces are placed around the kiln, and blasts of air forced through the fuel and through the top of the fire space.

The upper end of the kiln is arched over, and the feed-hole stopped with a removable cover having a perforation in its center.

In *D* the kiln has bottom discharge ; the furnaces are arranged on each side and discharge into the kiln. A cross-arrangement of flues counteracts inequality of draft on the windward and leeward sides.

A kiln, invented by Mr. Booker of Dublin, having the form of two truncated cones joined at their bases, where the diameter is about 7 feet, tapering to 3 feet at top and bottom, and from 25 to 30 feet in hight, is said to have produced excellent results. A pivoted plate of iron is placed over the top for regulating the draft.

Artificial hydraulic lime is now manufactured on a large scale in England and France, and has been employed in a number of important works.

Two qualities are prepared by two different processes. The first, which produces the best lime but is most expensive, consists in mixing with rich slaked lime a certain proportion of clay, and calcining the mass.

In the second, some soft calcareous material is substituted for the lime, and the materials incorporated by grinding.

In an establishment at Meudon, near Paris, the materials made use of are the chalk of the vicinity and a clay from Vaugirard, in the proportion of four chalk to one clay. These, broken into lumps, are thrown into a circular basin, around which an upright millstone, having its axis attached to a vertical shaft, is caused to travel ; this is provided with a follower, consisting of a wheel having attached toothed arrangements ; by this the mixture is, with the addition of water, ground into a pulp, and is drawn off, descending successively into a series of chambers at different levels, until it attains the proper consistency for molding. The mass is then divided into regular and equal prisms by means of a mold, and these are placed on drying-shelves until sufficiently dry for burning.

Cato (150 B. C.) gave directions for forming a lime-kiln. He preferred a truncated cone, 10 feet in diameter at the bottom, 20 feet high, and 3 feet diameter at the top. The grate covered the whole bottom ; there was a pit below for the ashes, and two furnace-doors, one for drawing out the burnt stone and the other for admitting air and fuel.

Lime-light. A light produced by projecting jets of ignited hydrogen and oxygen upon a ball of lime.

Invented by Lieutenant Drummond, who first applied it in the focus of a paraboloid for geodetic purposes. See DRUMMOND-LIGHT.

Lime-ma-chine'. (*Gas-making.*) A machine in which gas is purified by passing through lime. See GAS-PURIFIER.

Lime-paste. The cream of lime, produced by slaking with water.

Lime-pow'der. The decrepitated lime produced by air-slaking.

Lime-screen. A sifter for separating lime powdered by slaking from the lumps.

Lime-spread'er. A traveling box with perforated bottom, or other device, for distributing powdered lime over land as a manure.

Lime'stone. A rock composed of lime and carbonic acid.

The term in a geological sense includes *chalk* and *marble*, but technically these are distinct.

Limestones are often fossiliferous ; in the metamorphic limestones, such as *statuary marble*, the traces of fossils are obliterated.

Siliceous limestones are mixtures of carbonate of lime and flint.

Magnesian limestone, dolomite, is a compound of carbonates of lime and magnesia.

Chalk is an aggregation of fossils, large and small. The latter are microscopic.

Oolite is composed of small, egg-like grains, each of which has a grain of sand as a nucleus, covered by concentric layers of carbonate of lime.

Pure carbonate of lime occurs in the form of calcareous spar, but is generally associated with other minerals. According to its combinations it is known as : —

Argillaceous.	Ferruginous.
Magnesian.	Bituminous.
Sandy.	Fetid, etc.

According to its texture it is known as : —

Lamellar.	Oolitic.
Saccharoid.	Chalky.
Granular.	Pulverulent.
Compact.	Concreted, etc.

Lime'stone-me'ter. An instrument invented by Dr. Ure for ascertaining the proportion of calcareous matters in soils. See Ure's Dictionary, II. pp. 689, 690 (Am. ed.).

Lime-wa'ter. A solution of lime prepared by mixing hydrate of lime with boiling distilled water.

Lim'ing. 1. (*Leather-manufacture.*) The operation of steeping hides in lime-water or milk of lime, to remove the hair. The action of the lime is to dissolve the hair sheath and form a soap with the fat of the hide. *Unhairing.*

2. Slaked lime thinned with water, used in bleaching.

Limp. The sheet-iron scraper wherewith the top layer of poor ore is removed from the sieve.

Linch-pin. (*Vehicle.*) A pin passing vertically through a mortise near the end of the *spindle* or *arm* of an *axle*, and serving to hold the wheel on the spindle. The ring on the end of the axle is the *linch-hoop*.

With *thimble-skein* wagons, a nut takes the place of the linch-pin. See AXLE.

The chariots of Egypt had two wheels, with 6 spokes each. Sometimes the wheels were fast to the axle like our railroad wheels; sometimes they ran upon the axles, like our carriages: in the latter case, they had bronze *linch-pins*, as shown at Aboosimbel and at Thebes. No screw in old Egypt.

Line. 1. (*Fiber.*) The finer and longer stapled flax separated from the shorter, *tow*, by means of the HACKLE (which see).

2. (*Printing.*) An arrangement of letters and words across a page or column.

3. The twelfth of an inch.

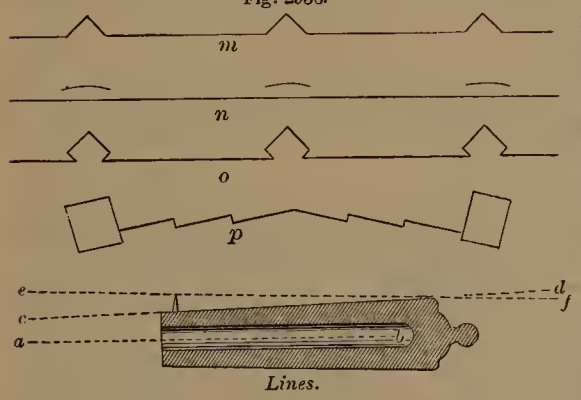
4. A measuring cord, or one for tying or suspending objects, as a *tape*-line, *clothes*-line, *chalk*-line, etc.

5. (*Machinery.*) *a.* The truth of position; as an engine *in line*, that is, the motions of the piston, pitman, and crank-wrist in the same plane, and at right angles to the axis of the fly-wheel.

b. The line of centers. The dead point of a crank, when the connecting-rod and crank are in a straight line.

6. (*Fortification.*) A rampart. Continued lines

Fig. 2956.



Lines.

are used to inclose a front or to connect principal works with one another by a continuous parapet.

Redans, *tenailles*, or *bastions* are placed at intervals, for flank defense, and give rise to the terms, —

Redan line (*m*).

Tenaille line (*n*).

Bastion line (*o*).

Indented lines (*p*) have a succession of *faces* and flanks at right angles. The *faces* are four times the length of the *flanks;* the latter have an enfilading fire on the *faces* of the parapet.

Names defining position and relation are: —

Line of defense: extending from the projecting angle of a work to the exterior extremities of the flanks which defend it.

Line of circumvallation: a belt of field-works two or three miles from the place invested, facing the country.

Line of contravallation: a belt of field-works facing the place attacked.

Line with intervals: one having detached works which command the intervening space and enable them to support each other.

7. (*Shipbuilding.*) A delineation of the form of a vessel, representing vertical and horizontal sections.

a. Beam-line. The line indicating the intersection of the top of the beams with the frames of the ship.

b. Bearding-line. The trace of the inner surface of the ship's skin upon the *keel*, *stem*, and *stern-post*.

c. Boundary-line. The trace of the outside surface of the skin, corresponding to the outside edge of the rabbet.

d. Bow and *buttock* lines are the boundaries of the vertical sections of the ship, in planes parallel to the vertical longitudinal section.

e. Center-line. The central, vertical, longitudinal section.

f. The *cutting-down* line is a curve on the sheer plan, corresponding to the upper surface of the throats of the floors amidships and to the under side of the keelson.

g. Diagonal lines show the boundaries of various sections formed by planes which are oblique to the vertical, longitudinal plane, and which intersect that plane in straight lines parallel to the keel.

h. Level lines are similar to the water lines, excepting that they are parallel to the keel instead of to the surface of the water, or the *line of flotation*.

i. The *main-breadth* line is the boundary of the widest part of the ship in each of the three plans, — the *shear-plan*, *half-breadth plan*, *body-plan*.

j. Ribband-line. An oblique longitudinal section. See *Diagonal* line.

k. Sheer-line. The line of the deck at the side of the ship. The upward curvature towards the ends is called the *sheer*, and the effect is to raise the vessel to a greater hight out of the water at the stem and stern, where her motion relatively to the water is greatest.

l. Stepping-line. The *bearding*-line at the points where it curves upward towards the ends of the vessel.

m. The *top-breadth* or *top-timber* line is a line drawn to the sheer of the ship, fore and aft, at the hight of the under side of the gunwale amidships.

n. The *top-side* line is a sheer-line drawn above the *top-timber* line at the upper side of the gunwale.

o. Water-lines are straight and horizontal in the *sheer-plan* and curved in the *half-breadth plan*. They show the form of the ship at successive depths, as would appear by so many horizontal sections.

8. (*Nautical.*) *a.* A running cord or rope; as, *bowline*, *bunt* line, *clew* line, *spilling* line, etc.

b. A cord for a specific purpose; as, a *hand*-line, a 20-fathom sounding-line having a lead of from 7 to 14 pounds (see HAND-LINE). A *deep-sea* line, one of say 200 fathoms, and having a lead of 28 pounds weight (see DEEP-SEA LINE). A *fishing*-line.

c. A grade of rope, such as *marline*, *white* line, *tarred* line, etc.

9. (*Mining.*) *a. Line of bearing.* The strike of a stratum, or its direction at right angles to the *dip*.

b. Synclinal line. The axis of the valley curvature of strata, opposed to *anticlinal*.

c. Anticlinal line. The axis of the ridge or saddle curvature of strata, opposed to *synclinal*.

d. Line of least resistance. The *line of mine* or *axis of explosion.* A line drawn from the focus of a mine to that point in the direction of which the charge meets with the least resistance.

10. (*Architecture.*) *Springing* line. The line from which an arch rises, and from which the versed sine is calculated.

11. (*Masonry.*) The bricklayer's cord, which is his guide for level and direction. It is stretched between *line-pins*.

12. (*Railway-engineering.*) A railway-track, as

the *main* line or trunk. A *loop*-line, a *connecting* line, a *crossing* line, a *side* line or switch.

13. (*Telegraphy.*) The wire connecting one station with another.

The part of an instrument to which the *line* is connected is known as its *terminal*.

The wires and instruments form the *circuit*. See CIRCUIT; WIRE.

14. (*Surveying.*) *a. Base-line.* A carefully measured line which extends between two stations and forms the basis of triangulation.

b. Line of direction. The *bearing.* The line laid down or protracted in a survey.

15. (*Drafting* and *Perspective.*) *a.* The *ground* line or *fundamental* line. The common section of the ground plane and the base of the picture. The *terrestrial* line.

b. The *horizontal* line. The common section of the horizontal and that of the draft of representation, passing through the principal points.

c. The *visual* line. The line conceived to proceed from the object to the eye.

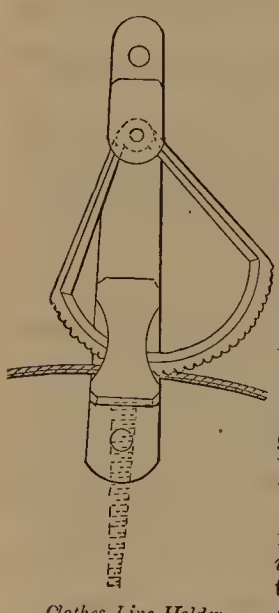
d. The *principal* line. A line drawn from the eye perpendicular to the picture. The *line of distance.*

16. (*Carpentry.*) To strike a straight line on timber or boards; usually a chalk line between points determined by measurement.

Lin'e-ar Mi-crom'e-ter. (*Optics.*) A graduated scale placed in the field of a telescope, and used to measure distances between objects.

Line-clamp. A device to hold a clothes or other line.

Fig 2957.



Clothes-Line Holder.

In the example, the line is clamped between the hook and the serrated swinging segment.

Lined-gold. Gold backed by a leaf of baser metal.

Line-en-grav'ing. This term is used to distinguish it from *aquatint*, *mezzotint*, and *stipple* or *chalk* engraving. It was originally entirely executed with the graver and *dry point.* The latter term is to distinguish it from the *etching point*, which makes a mark through a *ground* upon the plate, which is afterwards *bit in* with acid.

Latterly, the subject is first *etched* and then *finished* with the graver. Certain parts are left to be entirely executed by the graver and dry point, while other parts are deepened and made more effective by the application of the graver to the etched lines. Smooth portions are laid in by the *ruling-machine*, which has a *diamond-point* working through a ground upon the plate, and so arranged as to make a series of parallel marks at regulated distances. After *ruling*, the plate is *bit in* with acid, as described under ETCHING. (See RULING-MACHINE, ENGRAVER'S.) Line-engraving is generally admitted to be the highest style of the art.

Lin'en. (*Fabric.*) A cloth made of flax and having many grades of fineness, and several forms distinguished by their figures or surfaces; as *damask, diaper, cambric, huckaback*, etc.

The earliest notice of linen — cloth of flax — is in Egypt. In the time of Moses, the Pharaoh was arrayed in vestures of fine linen; and on the tomb of Beni Hassan are shown the pulling of the flax and the ridding of the seeds by means of the ripple. It was the only material allowed for the garments of the priests and the bandaging of the dead. The ceremonial law of the Hebrews also prescribes linen for the priests. Cotton was then unknown, except as a curiosity. Wool was regarded as foul. We read of the Egyptian linen in Genesis, Chronicles, Proverbs, and Ezekiel. Pharaoh arrayed Joseph in vestures of fine linen, 1716 B. C. The mixture of flax and wool in a fabric was forbidden (Lev. xix. 19). Solomon had linen yarn brought out of Egypt (1 Kings x. 28).

"He [Aaron] shall put on the holy linen coat, and he shall have the linen breeches upon his flesh, and shall be girded with a linen girdle, and with the linen miter shall he be attired; these are holy garments."

Wilkinson states that the ancient Egyptian linen is far superior to the finest modern in general quality and the evenness of the threads. One specimen has 540 threads or 270 double threads in the warp, and 110 in the woof.

In the linen corselet given by Amasis of Egypt to the Lacedemonians, each thread, though fine, was composed of 360 other threads, all distinct. It was handsomely embroidered. The tomb of Rameses III. at Thebes showed a similar corselet, worked with figures of animals. Pliny notices the corselet of Amasis, shown in the temple of Minerva at Rhodes. See FLAX.

It was first manufactured in England by Flemish weavers, under the protection of Henry III., 1253. Before this, woolen shirts were generally worn. A company of linen-weavers was established in London, 1368.

The Presbyterians, who left persecution in Scotland in the time of the Stuarts, planted the linen manufacture in the North of Ireland, and were encouraged by William III. and succeeding governments.

Lin'en Pa'per. As with paper of cotton, bamboo, morus bark, and silk, it appears that the first manufacture of linen paper was in China. The Egyptians excelled in fine linen in very early times. About 1500 B. C., the Israelites left Egypt with stores of linen; and five hundred years afterward, Solomon imported linen yarn from thence. Yet, with all this, it does not appear that the people of any country bordering on the Mediterranean had conceived the idea of tearing these rags to pieces, making them into pulp, and then into a sheet. See PAPER.

The use of papyrus itself, though it so much preceded any true paper, is by many persons supposed not to have antedated the expedition of Alexander. Without the papyrus, which so long gave the Egyptians precedence in the matter of written records, they must have been reduced to the same straits as their neighbors, and have written on waxed tablets, linen cloth, palm leaves, bark, etc. The use of parchment was not yet, if we may credit the assertion that it was invented by the king of Pergamus as a substitute for the papyrus, on which an embargo was laid by the reigning Ptolemy, whoever he was.

The use of linen paper in Europe appears to have originated in Germany, about the eleventh or twelfth century, the exact date being undeterminable. We read of a German paper-mill at Nuremberg in 1390, one in England in 1343, in France, 1314, Italy, 1367. Linen paper, however, is yet preserved, containing documents of much older date.

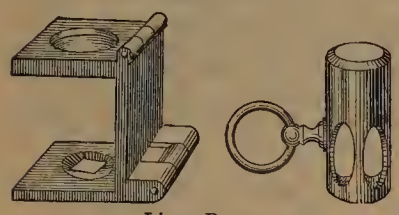
John Tate had a mill at Stevenage, England, in 1496, but the manufacture was much increased by

Spielman in 1588. This person was a German jeweler, and established a paper-mill at Deptford during the reign of Queen Elizabeth.

Whatman's mill was established at Maidstone in 1770. The name is yet a famous brand.

Lin'en-prov'er. A small microscope for counting the threads in linen fabrics. Its base has a square opening, which exposes a certain area of linen, and the glass above enables the number of threads to be counted.

Fig. 2958.



Linen-Prover.

Some linen-provers are provided with four perforations, which are respectively, —

$\frac{1}{4}$ of 1 inch. $\frac{1}{707}$ of 37 inches.
$\frac{1}{200}$ of 40 inches. $\frac{1}{200}$ of $\frac{3}{4}$ inches.

See Reed.

Line-of-bat'tle Ship. In England, a ship of not less than 64 guns.

Line of Cen'ters. (*Machinery.*) *a.* A straight line joining the centers of two wheels in gear.

b. The line when the crank and the connecting-rod are in a straight line. The *dead-point* of the crank.

Line of De-fense'. (*Fortification.*) A line joining a salient angle with the opposite flank. See Line, 6.

Line of Fire. (*Ordnance.*) The line formed by the axis of the piece produced. When the gun is laid point-blank, the *line of fire* is parallel to the *line of sight*, and not otherwise. See Fig. 2956.

a b, line of fire.
c d, line of metal.
e f, line of sight (point-blank).

Line of Met'al. (*Ordnance.*) A line joining the notches on the breech and muzzle, and forming an angle with the axis of the bore, in consequence of the taper form of the piece. See Fig. 2956.

Line of Met'al-el-e-va'tion. (*Ordnance.*) The elevation due to the conical form of the gun when the line of metal is laid horizontal.

Line of Sight. (*Ordnance.*) The line passing through the breech and muzzle sights of a gun at any elevation and the object. See Fig. 2956.

Line-pin. (*Bricklaying.*) A pin used by bricklayers to hold the line by which the bricks are laid. Its pointed end is forced into a mortar-joint of the building.

Fig. 2959.

Line-Pins.

Lin'er. 1. (*Marble-working.*) A long slab of stone to which pieces of marble are secured in order to be ground or polished. The pieces of marble — for a tesselated pavement, for instance — are placed face downward on a flat stone; plaster of paris is poured on their upper surfaces, and the *liner* is laid upon them so as to be cemented to each, though they may vary in thickness. They are then ready for grinding by being drawn back and forth over a large slab of marble, sand and water being supplied between the surfaces, which act by mutual attrition.

2. (*Machinery.*) A thin piece placed between parts to adjust them. A *shim*.

3. (*Nautical.*) *a.* A line-of-battle ship. One large enough to occupy a position in the main line.

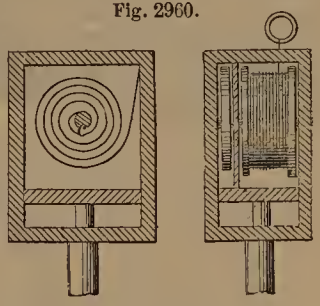
b. One of a regular line of vessels or packets sailing or steaming between ports.

Line-rock'et. (*Pyrotechnics.*) A small rocket made to run along an extended wire or line.

Lines. (*Saddlery.*) Another name for driving-reins.

Line-wind'er. A reel for a clothes-line, a fishing-line, a chalk-line, a log-line, etc. In the example, the line, after being withdrawn for use, is re-wound on the reel by a spring upon the reel-shaft.

Fig. 2960.



Cha'k-Line Reel.

Line-wire. (*Telegraphy.*) The wire connecting stations. They are usually of iron, on account of its comparative cheapness, and its tenacity, which allows a long reach between posts. See Insulator; Telegraph; and, for a specific index of related subjects, see Electrical Apparatus and Appliances.

Lin'gel. A small thong of leather for sewing or lacing bands. *Lingle.*

Lin'got. An iron mold for casting metals.

Lin'guet. 1. A tongue; as in some organ-pipes. A *languet*.

2. The piece of a sword-hilt which turns down over the mouth-piece of a scabbard.

Lin'ing. 1. (*Joinery.*) Inside boarding; in contradistinction to outside *sheathing* or *boxing*, called *casing*. A covering of an interior surface, such as —

The *boxing* of window-shutters which form the backs of the recesses into which the shutters are folded.

The *facings* on each side of a doorway.

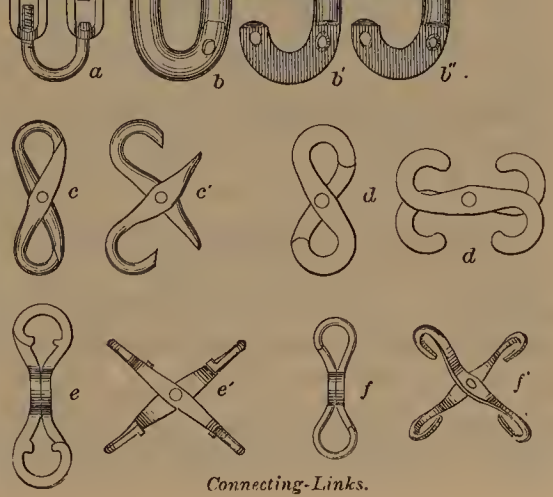
The vertical pieces of a window-way parallel with the surface of the wall.

2. (*Metallurgy.*) The *fixing* or protecting stuff on the boshes of a puddling-furnace. The inside surface material of a Blast-furnace (which see).

3. (*Steam-engine.*) A non-radiating covering of felt, etc., for a steam-boiler. The term is hardly correct here, for the covering is exterior, and is properly known as *cleading*, *lagging*, or *jacket*.

4. (*Hydraulic Engineering.*) Puddle laid on the sides of a canal, to prevent the percolation of water.

Fig. 2961.



Connecting-Links.

Link. 1. A short connecting piece of circular or other equivalent shape, as one of the oval rings or divisions of a chain.

The illustration shows several links capable of being taken apart, and thus becoming a means of uniting the broken ends of a chain. Each half of the link *a* has a swivel to which it is connected by a head, the swivel of each part forming a nut for the threaded leg of the other portion. The link *b* is made of two sections, *b' b''*, laid upon each other and riveted. The illustrations (*c c'*, *d d*, *e e'*, *f f'*) are forms of connecting link whose twin swiveling portions form a mousing for each other.

2. A short connecting bar with a bearing in each end, for transmitting motion from one rod or lever to another.

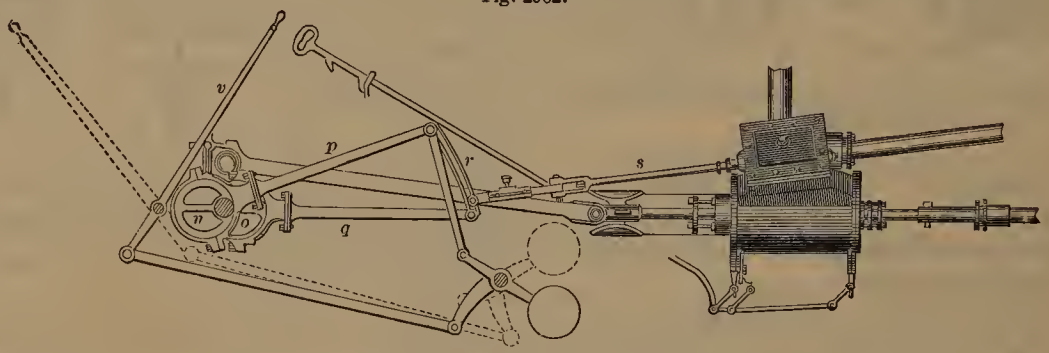
3. The length of one section of Gunter's chain, 7.92 inches, the 100th part of 66 feet.

4. A torch. It is made of tow and pitch, or of combustible splinters, such as of pitch-pine.

Link-mo'tion. A gear by which the valve is operated in locomotives and similar engines. It acts as a variable cut-off, or reverses the steam, or renders the valve inactive, as may be required.

It consists of two eccentrics *n o* and their rods *p q*, one for the forward and the other for the backward

Fig. 2962.



Link-Motion.

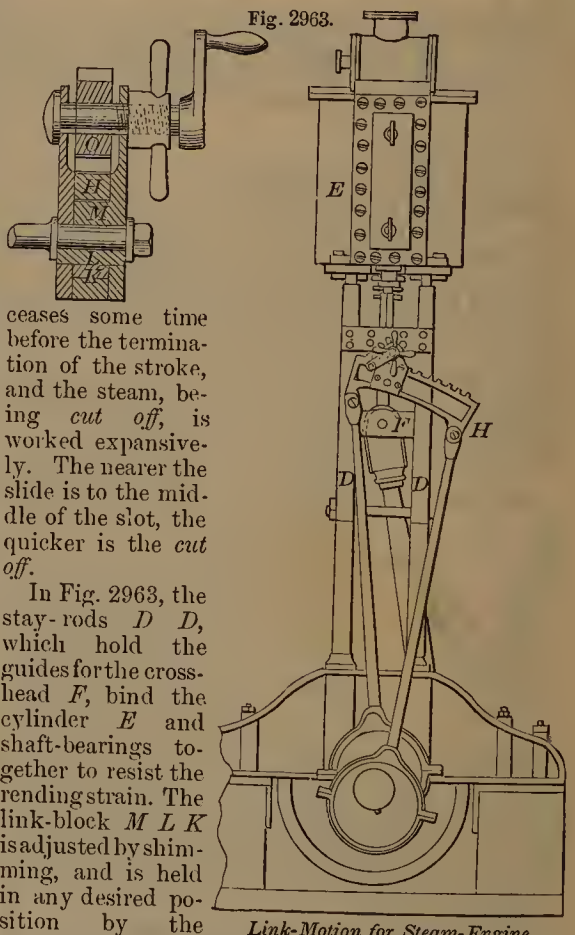
movement of the engine. The rods are connected to the respective ends of a slotted bar *r* called the *link*, which is vertically adjusted by an arrangement of levers terminating in a handle *v*, as shown. The valve-rod *s* is connected to a sliding pin which moves up and down in the slot of the *link* as the latter is adjusted vertically by the handle and connecting-levers previously referred to. The handle is retained at any *set* which may be given to it, by engagement with a notched segment-bar.

The motions of the valve are produced by an impulse imparted to the pin in the slot of the link ; as the pin moves, a longitudinal reciprocation is imparted to the valve-rod. The motion of the pin — which is furnished with a slide to adapt it to move in the slot of the link — is made up of the motions imparted to it by the two eccentrics ; and when the pin-slide is in the middle of the link, it is not moved at all, as the actions of the eccentrics just balance each other, and the link simply oscillates on the slide-pin as a center. When the link is thus adjusted, the handle being at the middle notch of the segment, the valve is inactive and the engine at rest.

When the slide-pin occupies a position either way from the said middle position in the link, it is thereby brought under the domination of the eccentric-rod, whose end of the link it occupies. The other eccentric-rod then forms a fulcrum, on which the link oscillates, carrying with it the slide-pin, and thereby operating the valve-rod and valve at a *full* stroke. By shifting the link *r* downward from the position shown in the figure, the eccentric *n* and its rod *p* are brought into activity, the rod *q* attaining a *nearly* absolute position, reversing the motion of the slide, and consequently of the engine.

When the slide-pin occupies a position in the link at any point between the middle and either end, it receives a motion therefrom great in proportion to its proximity to the end, and conversely. In such position, the motion of the valve is distinctly made up of the motions of the two eccentrics, as the fulcrum-point of the link is itself shifting, and the effect is to give the valve only a part of the throw of the eccentric. The steam-valves are partially opened, quickly closed again, so that the admission of steam

Fig. 2963.



Link-Motion for Steam-Engine.

ceases some time before the termination of the stroke, and the steam, being *cut off*, is worked expansively. The nearer the slide is to the middle of the slot, the quicker is the *cut off*.

In Fig. 2963, the stay-rods *D D*, which hold the guides for the cross-head *F*, bind the cylinder *E* and shaft-bearings together to resist the rending strain. The link-block *M L K* is adjusted by shimming, and is held in any desired position by the toothed link *H* and the pinion *O*. See Burgh's "Link-Motion and Expansion-Gear." London, 1871.

Link-worm'ing. (*Nautical.*) Worming a cable by chains inserted in the interstices of the strands.

Link-le'ver. (*Railroad-engine.*) The reversing lever of a locomotive.

Link-work. Work in which motion is communicated by connecting pieces.

Lin'net-hole. (*Glass.*) (Fr. *lunette.*) A hole connecting the glass-melting furnace with the arch.

Lin'seed-mill. (*Lint*, Flax.) A mill for grinding flax-seed for oil. See OIL-MILL.

Lin'seed-oil. Oil expressed from flax (*lint*) seed.

Lin'sey. (*Fabric.*) A country-made fabric, of linen warp and worsted filling, undressed; hence the name *linsey-woolsey.*

Lin'stock. A *lint-stock.* A gunner's forked staff, to hold a match of lint dipped in a solution of saltpeter. It is referred to by Shakespeare: —

> "And the nimble gunner
> With *linstock* now the devilish cannon touches."
> *Henry V.*

Lint. Raveled or scraped linen reduced to a soft state and used for dressing wounds or ulcers. As formerly prepared, it consisted of scrapings from the surface of old linen cloth, which was drawn beneath a knife, the weft-threads being pushed back from time to time, and the scrapings being obtained from the threads of the warp.

A machine has been used for the purpose, the straight, blunt knife-blade being brought down by a pedal upon the frayed edges of the linen, which lies upon a little leather-covered ledge beneath it. The linen is rolled upon a round stick whose length is in the direction of the weft-threads, and the edge of the piece, being pushed under the descending knife, receives a pull after the knife has supplied it, thereby raveling off the weft-threads and scraping the warp-threads. The art of using the machine consists in causing the knife to descend on the warp between the weft-threads at each descent.

Lint made up into a flat, oval form is termed a *pledget;* into a cylindrical form, or resembling a date-stone, it is a *dossil.*

A substitute for lint consists of carded or scribbed fiber, impregnated with vegetable tar to render it antiseptic and disinfectant.

Lint-doc'tor. A sharp-edged ruler on the delivery side of the calico-printing cylinder, to detain any lint or fibers which may come off the cotton cloth. The *color-doctor* on the other side of the roller acts as a wiper to remove superfluous color. See CALICO-PRINTING.

Lin'tel. (*Carpentry.*) A piece of timber laid horizontally over a doorway or window. An arch above to bear the superincumbent load is called a *discharging*-arch.

Lip. 1. A projecting flange, as on the edge of a kettle.

A narrow surface around an opening, as the *lip* of a bottle.

2. (*Music.*) In organ-pipes, the edge against which the sheet of air impinges. The vibration acquired thereby is communicated to the column of air in the pipe, and produces a musical note. See MOUTH-PIPE; PIPE.

3. (*Water-wheel.*) A rim closing the joint between the barrel and curb of a turbine.

4. (*Vehicles.*) A *cuttoo* plate. A projecting part of the bolster.

Lip-bit. A boring-tool adapted to be used in a brace, and having a cutting lip projecting beyond the end of the barrel. See BIT.

Lip-head Bolt. A bolt with a head projecting sideways.

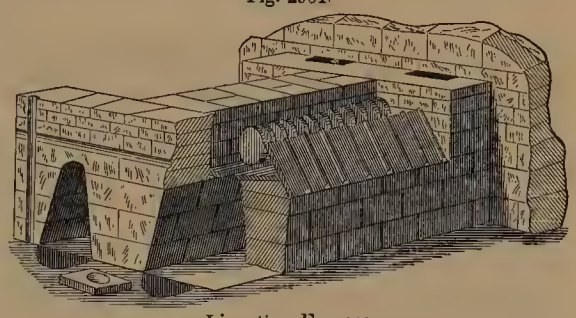
Li-qua'tion. Silver is separated from copper by melting the alloy with the addition of lead, and cooling the triple alloy suddenly in the form of cakes. These cakes are heated to such a degree on an inclined hearth as to cause the alloy of lead and silver to run off, and allow the copper to remain.

The lead and silver may be separated by cupellation or by Pattinson's process, in which the alloy is allowed to cool slowly and the crystals removed as they form, leaving the alloy relatively richer in silver. By a repetition of the process an alloy of great richness is procured, and the operation may be followed by cupellation, in which the lead is oxidized, melts, and runs off. See LEAD-FURNACE.

Li-qua'tion Hearth or Fur'nace. A hearth or furnace in which metals are separated by exposure to a heat which melts one or more of them, but leaves the other or others unmelted.

The disks of alloy — say, copper, lead, and silver — are set on edge in a slanting position on two iron plates, between which is an interval. Wedges are placed between the disks until the furnace is charged, and the space around the disks is then filled in with

Fig. 2964.

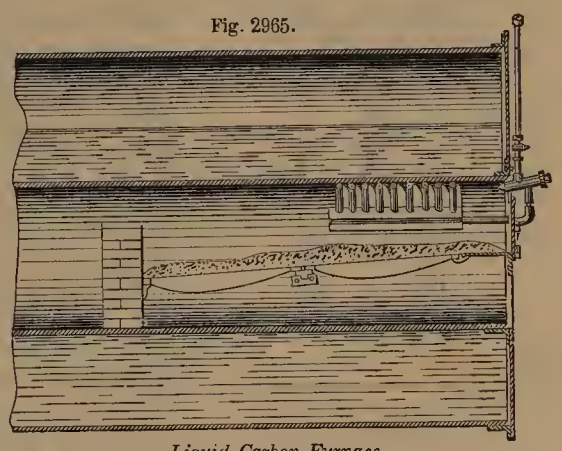


Liquation-Furnace.

charcoal, the top of the furnace restored, and heat applied to the kindling in the chamber below. As the temperature increases, the alloy of lead and silver, whose union is more intimate than that of either with the copper, becomes fused and runs down to a conductor on the bottom of the fire-chamber, and is led to the cistern in front, from whence it is ladled, the lead and silver being afterward separated by cupellation.

Liq'uid-car'bon Fur'nace. A furnace in which liquid fuel, such as petroleum, is introduced into the fire-chamber and burnt in contact with air and some-

Fig. 2965.



Liquid-Carbon Furnace.

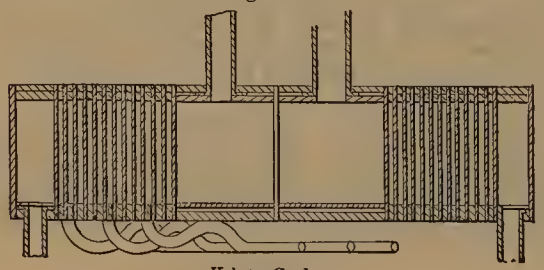
times with steam. The example has an injector above the fire-door, for the introduction of the liquid hydrocarbon; the supply is regulated by a cock, and

at the point of ejection it is associated with superheated steam at a temperature of about 600° Fah. The combined spray thus injected comes in contact with the hot ashes on the grate-bars, by which it is ignited.

In raising steam, fire is first made on the grate-bars in the ordinary way, and the injector is brought into action when the required pressure is obtained in the boiler.

Liq'uid-cool'er. An apparatus for cooling wort, beer, wine, water, etc. On a small scale, as the wine-cooler at the sideboard, it is a tub in which

Fig. 2966.



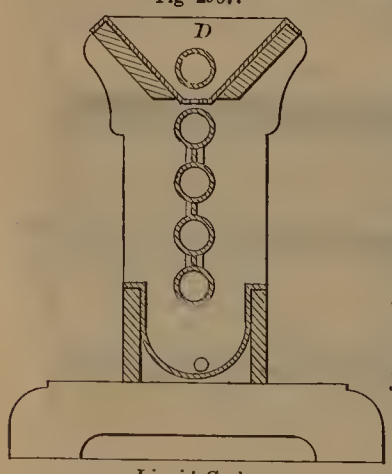
Volute-Cooler.

bottles are stood with broken ice around them. For soda-water and other liquids on draft, it is a coil of pipe which passes through a chamber, and is covered with pounded ice. For milk, it is a pan which has a false bottom, through which cold water circulates. For beer on draft, it is a chamber in which the keg is set with blocks of ice about it and the faucet projecting. See Fig. 632.

On a larger scale, used in breweries for cooling wort or beer, it has many forms. It is usually a very large shallow vat. One is shown in Fig. 2966. It is a volute, formed by a wide strip of metal set on edge between upper and lower heads. A long sheet-metal plate is folded and then convolved, so as to form a helix with two distinct spaces; the edges of the plate are attached to the top and bottom disks, which form heads, and one space in the convolution is for the refrigerating liquid, the other for the vapor or fluid to be condensed; induction and eduction passages admit and discharge the respective fluids.

In Fig. 2967, the beer, on its way from the *cool-beds* to the fermenting-tun, flows into the trough *D*, and thence trickles over the vertical series of horizontal pipes, through which cold water passes. Similar to this in construction is the Degrand condenser, except that the latter is for heating cane juice, and the pipes are filled with steam. See Fig. 1421.

Fig 2967.

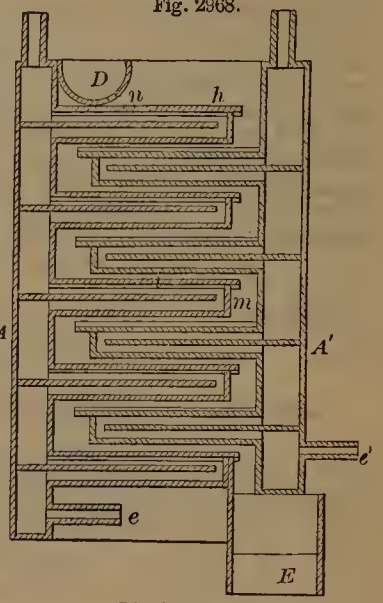


Liquid-Cooler.

The cooler in which the wort passes through a coil of pipe in a vat which is filled with ice, or through which flows a stream of cold water, is also like the coil-condenser in the arrangement of its parts. See Fig. 631.

Another form is that in which an outer and an inner vessel are filled with ice and communicate by short tubes which cross the intervening space; over these tubes the beer descends in a shower from a pan above.

Fig. 2968.



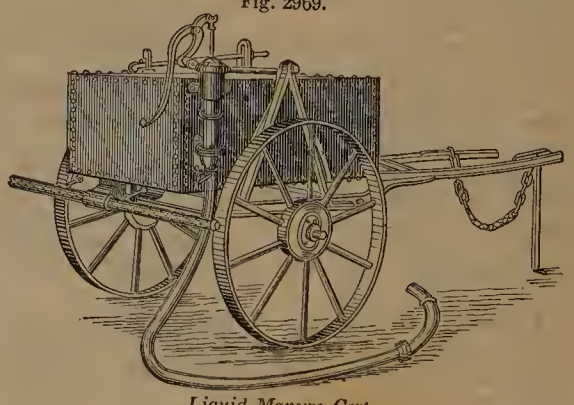
Liquid-Cooler.

Fig. 2968 has two vertical cases *A A'* in which wort circulates, discharging at *e* and *e'*. From each of these cases project boxes *h m*, which lap past each other in the intervening space through which water flows from *D* to *E*. In the cases are also plates which extend into the boxes, so as to form a sinuous channel through which the wort passes in a sheet against the outer walls of the box, which are cooled by the water.

Another form is a series of inclined troughs through which the wort passes to be cooled by exposure to the air.

Liq'uid-ma-nure' Cart. A tank on wheels for conveyance of liquid manure to a field and distributing it there. As shown, it is made of boiler-iron riveted, and is filled by means of a portable pump

Fig. 2969.



Liquid-Manure Cart.

and hose, shown in position. The tank is hung upon centers, so as to remain level on inclined ground.

Liq'uid-me'ter. A device for ascertaining the quantity of liquid received or discharged through an orifice. See METER, WATER.

It does not appear to have been in use prior to 1824, when William Pontifex of London, England, patented a new mode of adjusting or equalizing the pressure of fluids or liquids in pipes or tubes, and also an improved mode of measuring said fluids or liquids. This consisted in forming a chamber over the supply-pipe and near its end, in which was a leathern cup secured to the top of the chamber. A series of weights, one above the other, was also suspended from the top of the chamber, which were successively raised as the pressure of the liquid increased. An arm connected with the bottom of the

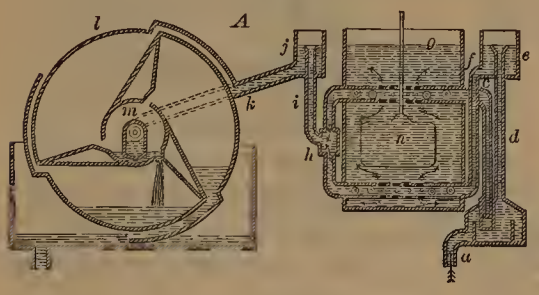
cup operated a valve, which gradually closed the discharge orifice as the weights were lifted.

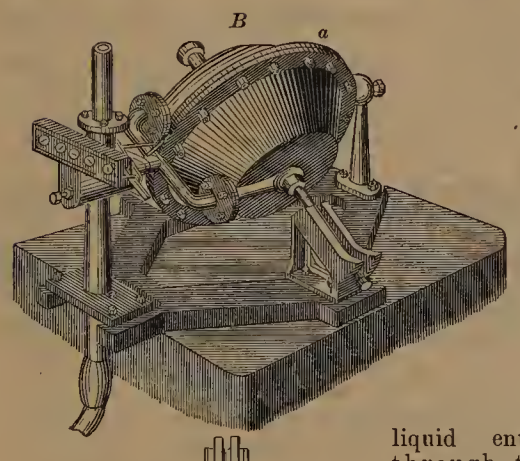
William Brunton, near the same time, invented a meter in which the reciprocating motion of a piston in a cylinder was caused to measure the amount of water discharged, the valve arrangements, etc., being similar to those of the steam-engine.

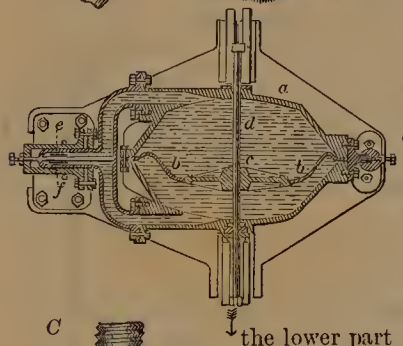
The forms of meter are various, the principal being known as the *diaphragm*, the *balanced*, in which compressed air is employed, the *piston*, the *propeller*, and the *flexible tube and roller* meter.

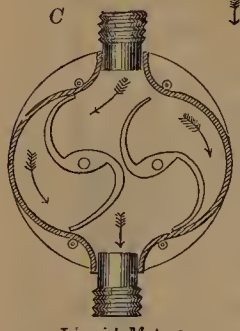
The spirit-meter of Siemens and Halske is shown in Fig. 2970 (*A*). This instrument is designed to register the quantity of spirit discharged, and also the amount of absolute alcohol contained therein. The

Fig. 2970.









Liquid-Meters.

liquid enters through the pipe *a* into the chamber, whence it passes through two pipes *c d*, one of which terminates in a chamber *e*, whence it is carried by the pipe *f* through the lower part of the vessel *g*. The other conducts it directly to the upper part of *g*.

The parts of the pipes which pass through *g* are perforated respectively on the upper and lower sides, causing upward and downward currents therein, thoroughly mingling the spirit, so as to insure that the quantity of alcohol contained in the spirit does not vary. The two meet in the chamber *h*, passing through a pipe *i* into a chamber *j*, from which it flows into the *volumeter* through the pipe *k*. The volumeter is a hollow drum *l*, having a concentric cylinder *m*, the space between the two being divided into three compartments. Three slits in the central cylinder permit the liquid to flow successively into each compartment, as it in turn occupies the lowest position. The openings are so arranged that while the lower chamber is filling the level is too low to permit an escape into either of the others, and the apparatus remains stationary until the lower chamber is full. The discharge of this then commences, while the aperture through which it received its supply is carried by the rotation above the liquid in the central chamber. To prevent overflow until this change of position has occurred, the discharge-channels are carried spirally from each chamber round the exterior of the one next following. The registering dials are actuated in the usual manner. The amount of pure spirit is determined by the indications of a hydrometer *n* in the tank *g*, having a curved lever, the shorter arm of which is connected with its stem. The hydrometer is filled with alcohol, and rises and falls according to the density of the surrounding spirit, causing the lever to vibrate each time that a chamber of the volumeter is emptied, to an extent indicating the quantity of pure spirit contained therein. A three-leaved cam, attached to the axis of the volumeter, is connected with the long arm of the lever, and is provided with a ratchet-wheel of large diameter with fine teeth. This is placed on the axis of the first register-wheel, and causes it to turn an amount equal to the movement of the curved lever.

The water-meter of Duboys of Paris (*B*) consists of a casing *a*, in the interior of which is a diaphragm *b*, carrying in its center a metallic disk *c*, the convex edges of which accurately fit the sides of the casing. The diaphragm and disk are kept in position by the rod *d*, which passes through water-tight orifices. *e* and *f* are apertures for receiving and discharging the water.

As the water enters through either duct, as *e*, it raises the diaphragm, forcing out the water on the upper side until the vessel is full, when the diaphragm fits closely against that side. During the process of filling, the vessel is inclined; but when the weight rises to the top, it gives that side the preponderance, causing the vessel to turn on its pivots until it becomes the bottom side. At the same time, the supply-opening is closed and that for discharge opened, while on the opposite side a contrary effect is produced. Arrangements are provided to prevent the vessel from tilting until it is entirely filled.

The meter of M. Clement of Orleans consists of an upright cylinder divided into five compartments, each of which is caused to actuate a crank on a vertical axis common to all. This carries a compound stop-cock, which admits the water to and discharges it from each compartment when filled.

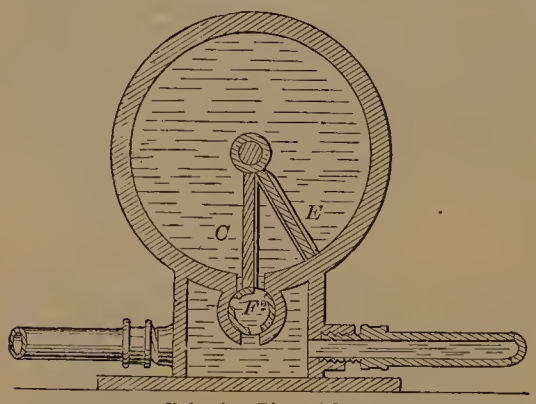
Payton's meter (*C*, Fig. 2970) contains two S-shaped arms, whose extremities during rotation are in close contact with each other and with the sides of the box. The arrows indicate the direction of the current. Similar devices are shown under Rotary Blower; Rotary Pump.

In Cochrane's meter for measuring liquids under pressure, the measurement is effected by a pivoted vessel resembling a double scoop, which tilts and discharges when either side is full. A bent lever below this is tilted back and forth at each movement of the scoop, actuating the registering mechanism.

Atwell's cylindrical case has a piston *E* which turns on an axial shaft communicating motion to the register, and carrying an arm which, at the end

of each stroke, changes a cylindrical valve F^2 so as to cause the water to alternately enter and discharge

Fig. 2971.



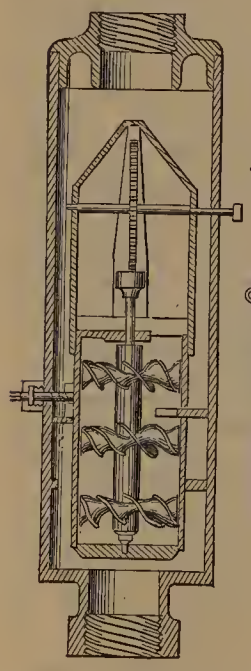
Pulsating-Piston Meter.

from the measuring-chamber at opposite sides of the internal partition *C*.

In Fig. 2972, a water-wheel within a pipe is connected to a register to indicate the flow of water. The flow is regulated by a sliding-valve.

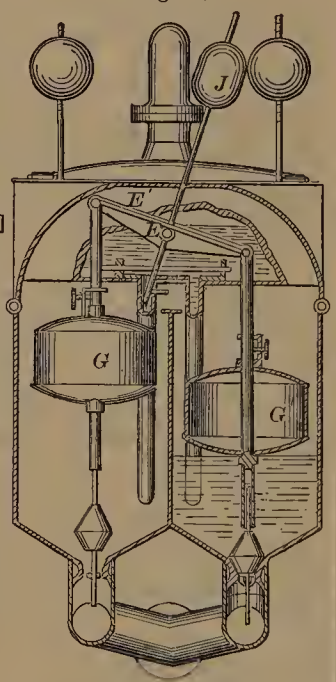
In Young's spirit-meter, floats *G* in the measuring-chambers are attached to each end of a pivoted beam. The alternate downward motion of the floats, as the chambers are discharged, diverts the induction flow from one to the other. The floats *G* and their valves occupy two chambers, and are suspended to opposite ends of the oscillating beam *E*. The valve-stems have a limited sliding motion in the

Fig. 2972.



Spiral-Vane Meter.

Fig. 2973.

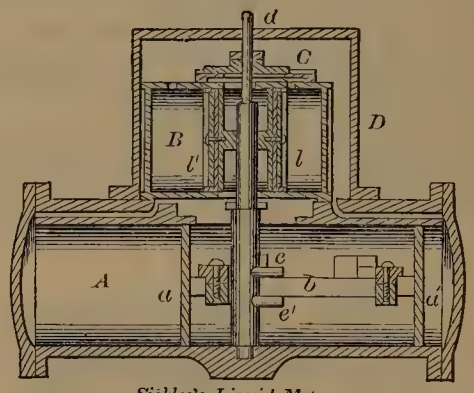


Young's Spirit-Meter.

floats, so that the float will rise to a sufficient hight without raising the valve to permit the emptying of the chamber. At the point of discharge the weighted rod *J* is thrown past the vertical, and, closing the valve to this chamber, opens the induction-pipe to the other chamber, depressing that float sufficiently to close the escape-valve.

In Sickles's meter (Fig. 2974) the liquid, flowing into the chamber *D*, is by means of the valve *C* admitted alternately to each end of the hollow valve *B*, which is divided into compartments by the partitions *l l'*. From these the fluid flows alternately through appropriate ports behind the pistons *a a'* on

Fig 2974.



Sickles's Liquid-Meter.

the rod *b*, which has tappets that strike the pins *e e'* on the upright shaft *d*, causing its partial rotation and operating the slide-valve *C*, which admits the fluid into the compartments of the valve *B*.

Liq'uor. 1. A term applied to a prepared solution, as, —

(*Sugar.*) A solution of sugar, used in claying the loaves.

(*Dyeing.*) A dye or mordant in solution, as *tin-liquor*.

Liquor of flints, liquor silicum; soluble glass.

Liquor of libavius; bichloride of tin.

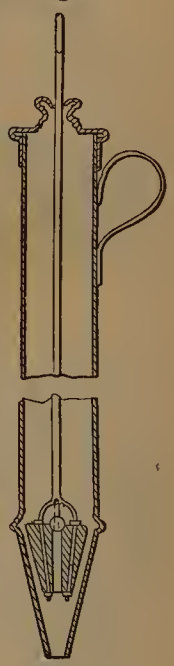
2. A dilution; as *liquor ammonia*, etc.

Liq'uor-gage. A measuring-rod for determining the depth of the liquid in a cask or tank. A part of the gager's equipment.

Liq'uor-pump. A portable pump for emptying casks, etc. See BURR-PUMP.

Liq'uor-thief. A tube which is let down through the bung-hole of a cask and then closed, so as to withdraw liquid therefrom. It is usually closed at top by the finger, but, in the illustration, the tube is closed by a plug. A *sampling-tube*. A *velinche*.

Fig. 2975.



Liquor-Thief.

Lisle-lace. A light, fine, transparent, white-thread, hand-made lace, so called from Lisle in France. It has a diamond-shaped mesh, formed by 2 threads plaited to a perpendicular line. Also known as *clear-foundation*.

Lis'sens. (*Rope-making.*) The ultimate strands of a rope.

List. 1. To chop a block or stave to an approximate shape; e. g. the balk or *codling* from which staves are to be rived is chopped to give a taper towards each end, before being cleft into staves by the *frow* and mallet.

2. (*Carpentry.*) *a*. The upper rail of a railing.

b. A narrow strip from the edge of a plank.

c. A small, square molding. A *fillet*.

3. A selvage (*self-edge*) strip on the edge of broadcloth.

4. (*Rope-making.*) A woolen flap in the hands of a rope-maker, through which the yarn goes.

5. *a.* A thin coat of tin preparatory to the thicker coat, in tinning iron plates.

b. A selvage or wire of tin formed on the under edge of plates in tinning.

6. (*Nautical.*) An inclination of a ship to one side. A *heel.*

List'el. (*Joinery.*) A narrow, slightly projecting ledge. A *reglet.*

List'er. A three-pronged fish-spear. See LEISTER.

List'ing. 1. Cutting away the sappy edge of a board.

2. The narrow edge of a board.

List-pan. (*Tin-plate manufacture.*) A perforated skimmer.

List-pot. A heated pan with a small quantity of tin at the bottom, and the last of the series of five pans used in the manufacture of tin-plate. *Tin-pot, wash-pot, grease-pot, pan, list-pot.* See TIN-PLATE.

Lith'arge. Semi-crystalline or fused protoxide of lead, obtained in separating silver from lead ore, and used in the composition of flint-glass.

Lith'ic Paint. A mastic of petalite (which contains an alkali known as lithia), sand, and litharge, used as a coating for walls.

Lith'i-um. A metal, the base of lithia.

Equivalent, 6.9; symbol, *Li.* This rare metal somewhat resembles sodium, and has no special interest in a mechanical point of view. Specific gravity, 0.59; fusing-point, 356° Fah.

Lith'o-clast. (*Surgery.*) A powerful forceps-like instrument, with two blades having concealed chisel or wedge shaped projections to cut the stone in the bladder into pieces, if found to be too large to extract by means of the lithotomy-forceps after the operation of lithotomy.

Lith'o-col'la. A cement for uniting stones. See CEMENT.

Lith'o-frac'teur. Composed of nitro-glycerine, 52 per cent; infusorial silica and sand, 30 per cent; carbon, 12 per cent; $NaO\ NO^5$, 4 per cent; sulphur, 2 per cent.

Its characteristics, as compared with dynamite, are: (1) greater sensitiveness to temperature, exploding at 120°, while dynamite explodes at 190°; (2) greater sensitiveness to moisture from the presence of the hygroscopic nitrate of soda; (3) the gases from the explosion always contain carbonic oxide from the carbon in the compound; (4) for equal volumes it has the less explosive power. — *Journal of Applied Chemistry.*

Lith'o-glyph. An engraving on a gem.

Lith'o-graph'ic Cray'on. In drawing on stone for the purposes of lithographic printing, crayons are used. They are composed essentially of soap, wax, fat, and lampblack, and are cast in the form of little cylindrical sticks. These are fastened in a porte-crayon or quill in the ordinary way. The above constituents, with various additions of shellac, mastic, etc., are fused together and finally set on fire. The longer the mixture burns, the harder the product becomes; three or four grades are usually made.

A grained lithographic stone is always required for a crayon-drawing; that is, a stone to which an evenly roughened surface has been given by grinding it carefully with sharp sand of a uniform character. The asperities upon the surface of such a stone remove the substance of the crayon in quantity proportionate to the pressure employed by the artist. When finished, such a drawing appears to the eye exactly as the impressions on paper printed from the same stone are intended to look. The printing capability is possessed by a crayon-drawing only after it has been etched with a very weak acid and gum-water. See LITHOGRAPHY.

Lithographic crayon or chalk (Engelmann): —

Yellow wax, 32 parts; Marseilles soap, 24 parts; tallow, 4 parts; saltpeter, 1 part; lampblack, 7 parts.

Melt the wax and tallow first; add the soap gradually, and heat till the mixture catches fire of itself. Remove the vessel from the fire, and let its contents burn for about two minutes for soft, and three minutes for hard, crayons. Extinguish the flame, and add very gradually and carefully the saltpeter dissolved in 7 parts of water. Heat is now to be applied with constant agitation, till the mass again takes fire, when it is to be instantly extinguished and the lampblack added. Mix very thoroughly, and heat till combustion once more takes place, which is to be instantly checked as before. It now remains to test the quality of the crayon as to hardness, and the quality of the point which can be given to it. A sample is poured out for this purpose, cooled, cut into strips, and left standing a day. If soft, farther burning will harden the product; but it can only be softened by adding an extra soft quality of crayon. When satisfactory, the mass is melted and poured into suitable molds. There are many other recipes for making crayons, involving the use of resins, etc., but the above is the simplest, and without doubt one of the best. Lemercier's formula is but a rehash of the foregoing, and the same may be said of Korn's, save that he does not set fire to his mixture, but prolongs the time of melting immensely, to attain the hardening of the mass.

Lith'o-graph'ic Ink. Lithographic ink, adapted for drawing on stone, is a compound similar to that used for LITHOGRAPHIC CRAYONS (which see), save that soap enough is present to render it quite soluble in water. It is rubbed up like india-ink, and used with a pen or very small hair-pencil, mostly on smooth stones. The usual preparation with acid and gum-water fits the work done with it for printing.

The same, or an ink quite like this, is also used for writing on *autographic transfer-paper.*

Transfer-ink is used for transferring from one stone to another, or from an engraved plate to stone, also for photo-lithographic transfers. It is composed of fatty and resinous bodies fused together, and often burned. Soap is frequently added in small quantity, and it is always colored with lampblack. Transfer-ink is used with a roller, like printing-ink, or with a *tampon* or pad, when transfers are made from engraved stones. This ink is sometimes called re-transfer-ink, in allusion to the fact that the printing surface is sometimes formed by a second transfer.

Printing-ink for lithographic purposes is very similar to that used by the type or woodcut printer. In the latter, boiled oil, resin-oil, and similar adhesive fluids serve as a vehicle for the carbonaceous or mineral matter which gives the color. In lithographic printing, the nature of the oily substance ground with the lampblack, or color, is all important; for upon its affinity for the design upon the stone, and its repulsion for the damp portions, depends the possibility of printing. Experience has shown that *burned linseed-oil*, technically known as LITHOGRAPHIC VARNISH (which see), is admirably adapted for the manufacture and thinning of lithographic ink. The treatment such varnish has been subjected to, while it does not seriously lower its affinity for the lithographic picture, or its repulsion for the gummed and damp parts of the stone, will be found to have deprived it completely of its greasy character, which would gradually tend to smear and cloud the work.

In the manufacture of black ink, the quality de-

pends a good deal upon that of the lampblack used; but chiefly upon the thoroughness of the mechanical process by which it is ground. It comes into the market as an exceedingly tough paste, made up in closed cans. The lithographic printer thins this with varnish of appropriate consistence, to suit his requirements, using the muller and pallet-knife to make the mixture thorough and uniform.

Recipes for a variety of lithographic inks are appended hereto.

Lithographic ink for drawing and writing on stone with the pen (Desmadryll, Sr.): White wax, 40 parts; mastic, 10 parts; shellac, 28 parts; white soap, 22 parts; lampblack, 9 parts.

The wax is heated in a suitable vessel till it continues to burn when set fire to. It is then removed from the fire, and the soap, shellac, and mastic added in small quantities at a time, but not fast enough to extinguish the flame. When all the ingredients are mixed, the cover is put on the pan, so as to stop farther combustion; the lampblack is now added, and the whole heated once more till it catches fire; the flame is extinguished at once, and the ink is examined after cooling. If it gives a solution which too soon becomes gelatinous or sticky, it must be burned more.

Another recipe, which gives a softer ink, is the following (Desmadryll, Sr.): Tallow, 10 parts; wax, 10 parts; soap, 16 parts; shellac, 14 parts; lampblack, 5 parts.

Fuse together and treat exactly as above.

The following is Lemercier's recipe for a similar ink: —

Yellow wax, 4 parts; tallow, 3 parts; white Marseilles soap, 13 parts, shellac, 6 parts; lampblack, 3 parts. Melt the wax and tallow, and add the soap in small quantities, then the shellac, and stir till all is evenly blended. Raise the temperature till the vapors take fire, burn cautiously for from one to two minutes; the lampblack is to be added next, and well mixed, and heat continued for a quarter of an hour. The ink is then poured out on a slab, cooled, and again melted with moderate heat, and constant stirring. The second melting is supposed to effect a more thorough blending of the constituents.

Ink for working on stone with the hair-pencil (Engelmann): —

Wax, 6 parts; soap, 6 parts; tallow, 3 parts; lampblack, 2 parts. Melt together and burn for a short time.

Ink for autographic transfer (Engelmann): —

Shellac, 16 parts; white wax, 10 parts; soap, 8 parts; dragon's blood, 8 parts; tallow, 5 parts. Melt the wax and tallow till ready to take fire; add the soap gradually in small pieces, and let the heat rise to the point of combustion. Add, while burning, the shellac and dragon's blood, and continue the burning for about five minutes. One part of this mixture dissolved in eight parts of hot water gives a good ink.

Another recipe (Cruzel) is as follows: —

White wax, 8 parts; white soap, 2 parts; shellac, 2 parts; lampblack, quantity sufficient. Melt the soap and wax together, then add the lampblack, of which there should be no more than will just color the ink when dissolved. Burn for about half a minute, put out the flame, and add the shellac with constant stirring. Heat is again applied till the mixture takes fire, after which it is cooled.

Mantoux obtained the gold medal from the *Société d'Encouragement*, for the following autographic ink: —

Gum-copal, 6 parts; wax, 10 parts; tallow, 10 parts; soap, 8 parts; shellac, 10 parts; gum-mastic, 10 parts; sulphur, 1 part. Heat the copal till it begins to crackle; then, to facilitate its fusion, add a small quantity of olive-oil. When melted add the tallow and wax. Heat and ignite, and add the soap quite dry and in little pieces. When melted and while still burning, throw in the mastic and shellac. The sulphur is now stirred in, whereby the heat will be increased, and the union of the copal with the other ingredients accomplished thoroughly. The flame at this stage of the process is to be extinguished, but after cooling a little the whole is again heated, and set fire to, and let burn moderately till the volume of the whole is reduced to one fourth of what it was. This ink is to be dissolved in ten parts of hot water; it is difficult to make, but is said to be one of the very best.

Ink for transfer from stone to stone: —

Wax, 1 part; soap, 1 part; tallow, 1 part; varnish, 4 parts; Venice turpentine, 6 parts; stiff printing-ink, quantity sufficient.

These substances are melted, and thoroughly mixed with the muller on a slab slightly warmed, the proportion of printing-ink being kept as small as possible. If too thick for use, more varnish is added by the printer, according to his judgment, at the time of pulling the transfer-sheet.

The above recipe can only be regarded as typical of and one of the simplest of the infinite variety of compounds for transfer from pen and crayon drawings on stone, and also from engraved stones and plates. It may almost be maintained that there are as many formulas for transfer-inks of this kind as there are transferrers, each making his own favorite compound, often with imposing secrecy. As in many other cases, marked success in transferring depends more upon the man than upon any other single circumstance.

Lith'o-graph'ic Pa'per. For transfer purposes, Chinese paper (India proof) is much used. It is cut into large sheets, and prepared by coating one side evenly with starch-paste, applied with a sponge. When dry, a second coat is sometimes given. Such paper is used for transferring from stone to stone.

For autographic transfers, any good book or writing paper may be employed. The sizing on the latter is often considered sufficient, but for first-class work a coating of a solution of isinglass or gelatine, with an addition of gamboge, is generally used. For photo-lithographic transfers, *Saxe* paper is required to attain superior results.

For printing from lithographic stones, almost any paper is suitable which is fitted for type and wood-cut work. This is not so when a soluble chemical substance is present in the paper, such as chlorine, alum, etc. The fact that the stone is constantly wet causes such re-agents as the above to act upon it, and upon the drawing which takes the ink, even when the paper itself is not dampened, and a gradual but certain deterioration of the work necessarily follows. In the early days of lithography, when paper was made for mechanical printing processes only, difficulties were experienced in procuring it of suitable quality for lithographic printing. These difficulties no longer exist, manufacturers having much improved the bleaching and sizing of stock. Unsized paper, such as India proof and plate paper, usually printed damp, generally give the clearest and blackest impressions from stone. For crayon and close artistic work, one or the other is indispensable; but they are expensive and will not stand wear and tear, therefore sized papers of various kinds and qualities, as book, map, bond, are largely employed for commercial and professional work. On the lithographic power-press, paper more or less

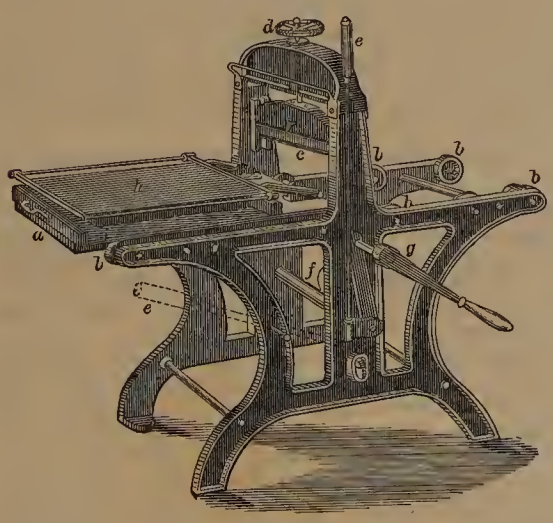
sized works better than that in which the fibers are easily disintegrated. On such presses dry paper is very desirable, therefore much attention is now being paid to smoothness and regularity of surface, which should lift the ink thoroughly without injuring the work, even on editions of many thousands from the same stone. Such papers are now manufactured, although greater perfection in this respect is still desirable, the power-press having created a demand for quality as well as quantity not dreamed of ten years ago.

Lith'o-graph'ic Pen. (*Lithography.*) Lithographic pens for writing on stone are now made by the best steel-pen makers, and are used to a limited extent. Such pens are exceedingly small and fine, even finer than a crow-quill, but the best lithographic pens are yet made by the artists themselves. They are made of thin steel ribbon, very slightly hollow, shaped and slit by a fine pair of scissors made specially for the purpose. These pens are not fitted for working on paper, but on the surface of the stone they give lines of extreme fineness unattainable in any other way.

Lith'o-graph'ic Press. The manner of applying pressure to a lithographic stone for the purposes of printing or transferring differs essentially from that employed for analogous work in the type and copperplate hand-presses. In the latter two, up and down pressure of the platen, or the progressive rolling pressure of the cylinder, is employed; in the former, a scraper is used. In power-press printing, however, it will be seen that these distinctions do not hold good.

The lithographic hand-press consists of a frame provided with rollers *b b b*, on which the carriage *a*

Fig. 2976.



Lithographic Hand-Press.

runs to and fro. The scraper *c* consists of a flat piece of boxwood, beveled from both sides to about a quarter-inch edge, and firmly clamped in the sliding iron piece above. The hight of the scraper above the carriage can be adjusted by the screw *d* to suit the varying thickness of the stones. The manner of printing is as follows: The stone *i*, with the design upon it, is placed face up upon the carriage; it is damped and inked, and the sheet of paper which is to receive the impression is laid thereon. The tympan *h* of leather, stretched in an iron frame, is then lowered upon it, as in the figure, and the carriage pushed under the scraper. By depressing the lever *e* to the position indicated by the dotted lines, the toggles at each end of the shaft *f* raise the bearings of the winch *g*, upon the axle of which a strong iron roller is made fast. This roller, or cylinder, is the full width of the press, and the depression of the lever brings it into contact with the under side of the carriage, lifting the latter at the same time off the rollers *b b b*, and pressing the forward end of the stone against the edge of the scraper. By revolving the winch-handle, the stone is slowly dragged under this stationary edge, which applies its pressure progressively through the leather of the tympan, to a narrow strip of the work, the result being equivalent to a very much greater crushing force applied over a larger surface. When the whole of the design has passed under the scraper, the lever *e* at the side is restored to its upright position, the carriage falls upon the rollers *b b b*, it is brought back by hand, the tympan lifted, and the printed sheet removed.

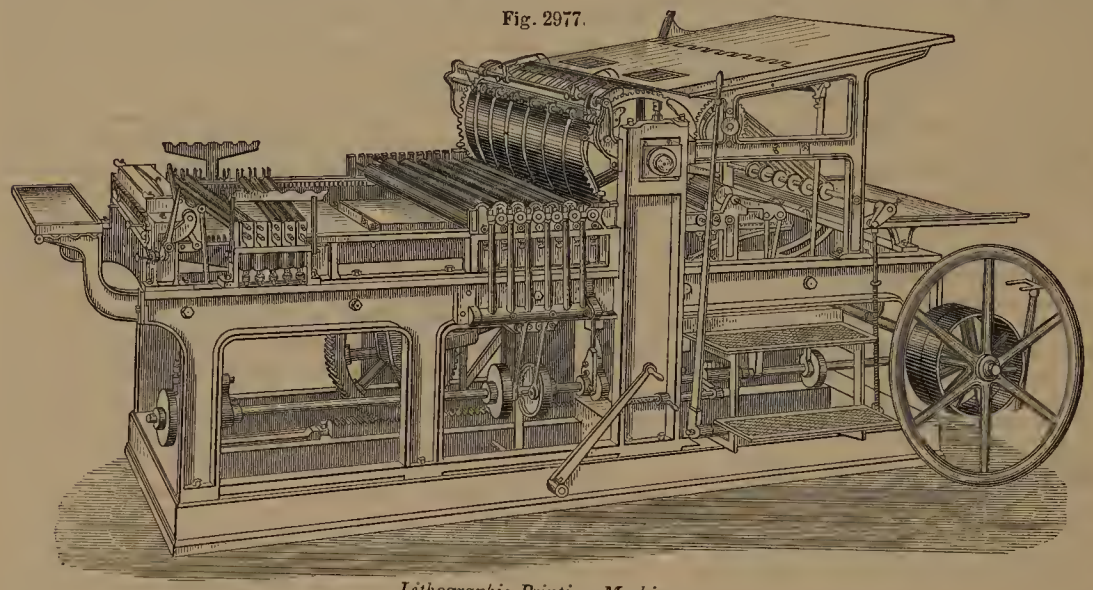
This, with unimportant modifications, is the form given to the lithographic hand-press in England and America. In Germany, Belgium, and France, presses of this construction are rarely seen. In Prussia, for instance, a press is used, occupying nearly double the space, but admirably constructed and well adapted for the execution of first-class work. In this machine, the scraper and its holder swing from the side across the carriage, the holder or *head* is then locked, and the pressure applied by a compound lever with the foot. The carriage is then drawn through by a broad girth or belt, one end of which is made fast to it and the other wound about an axle of small diameter at the extreme end of the frame, rotated by a *star* similar to that of a copperplate-press. The result is an exceedingly steady and uniform motion, but the loss of time as compared with the English press is considerable.

In the construction of lithographic power-presses, the scraper principle has been tried without success; power has long been and is still applied to the ordinary hand-presses, to relieve the workmen from the labor of pulling the carriage through; but for all automatic presses driven by steam, a cylinder of large diameter is now employed to apply the pressure. Since 1865, many press-builders in Europe and America have turned their attention actively to this subject, and produced serviceable machines. One of the most satisfactory presses of the kind, though not the earliest, is that now well known as Hoe's Steam Lithographic Machine. It is a stop-cylinder press, or one in which the cylinder comes to rest pending the adjustment of the sheet. The paper is fed to grippers on the cylinder from the inclined table above. The traveling-bed, on which the stone rests, is drawn under the cylinder by a crank and connecting-rod from the end of the frame below, and the cylinder, after being thrown into gear, is rotated at the same time (carrying the sheet with it) by a rack attached to the side of the bed. At the end of the stroke the cylinder goes out of gear, and remains stationary and locked during the return of the bed and stone; the latter passing under a cut-away part of the cylinder, so as not to come in contact with it. In place of a tympan, the cylinder is covered with a thin rubber blanket. The inking of the stone is effected by parallel rollers (from three to six) in front of the cylinder, upon which are heavy riding rollers of iron; the latter being made to vibrate laterally to aid the distribution of the ink. These inking-rollers are covered with leather, like the ordinary hand-rollers for lithographic printing; they receive their ink from a table which travels with the bed, and are driven by a rack or friction-pieces on the sides of the bed. The ink is fed to said table from a fountain at the end of

the press, and distributed by a number of oblique-lying rollers, also covered with leather.

The automatic damping arrangement is at the back of the cylinder. It consists of a shallow trough containing water, partially immersed in which a cylinder of wood is made slowly to revolve. An absorbent roller is held in contact with the wet surface of this cylinder for a longer or shorter time, accord-

Fig. 2977.



Lithographic Printing-Machine.

ing to the amount of water required upon the stone, after which it carries its increase of moisture over to a heavy riding-roller, which again gives it up to two damping-rollers covered with linen, which traverse the stone as it passes beneath them, just before it meets the inking-rollers at the other side of the cylinder; the feed of water admits of adjustment as to quantity, while the press is in motion.

The pressure in this press is adjusted by means of butting-screws, which lift or lower the bed in the traveling-carriage; these screws are turned by a key from above.

When the sheet is printed it is conveyed by an intermediate cylinder provided with grippers to the fly at the end of the press, and there deposited, face up, on the pile of printed work.

This press, though by no means identical with European machines of the same class, may be regarded as furnishing an illustration of the essential features of them all.

The introduction of the lithographic power-press has totally remodeled the lithographic trade throughout the world within the short period of four years (from 1868–72), increasing the possible production about tenfold. It has lowered the cost of, and, in fact, rendered possible, large editions from stone, which, in former times, found their way to the type-press with very inferior results. By this change the general public have profited largely.

Lith'o-graph'ic Roll'er. (*Lithography.*) Made of a stock of wood or metal, covered with a fold or two of woolen cloth, over which a *skin* of leather is drawn. The leather is of fine quality and shaved to an even thickness. The seam is made by turning the leather edge to edge and sewing it with silk, it being afterwards turned inside out. The *grain* or *hair* side of the leather is generally used for color-rollers, for the reason that it can be washed with turpentine, and for no other reason. Where a roller is kept for each individual color, as at Prang's chromo establishment, the flesh side is used for this as well as for black printing.

Hand-rollers are from 11 to 14 inches in length and 3½ inches in diameter. They have timber stocks for lightness, and the handles at the end are laid hold of by loose leather sleeves, in which the handles turn, and by compressing which, the printer, without blistering his hands, can produce a variety of effects. By a slow motion, with considerable pressure, the roller drags over the stone, depositing ink; by a quick motion and light pressure the tendency is to lift ink. In like manner the roller of close-grained leather deposits ink, while the tendency of a coarser grain of leather is to lift it. These considerations are of the greatest importance in developing the resources of the art of printing, for in this case it is an art.

Machine-rollers have a metallic stock, but in other respects are made as the hand-rollers. The expense of making them is much increased by the great length, which is sometimes as much as 50 inches. The improved method is now to drive them by friction disks running with the bed, whereby the speed of the rollers is rendered equal to that of the surface of the stone, preventing wiping action.

The capacity of a lithographic-printing roller depends upon the relative adhesion of the ink to the leather surface of the roller, and to the inked surface of the stone.

Lith'o-graph'ic Stone. A sedimentary limestone from the upper beds of the Jurassic formation. Lithographic stones of various sizes and weights are now articles of commerce all over the world. They are obtained almost solely from the extensive quarries of Solenhofen, in Bavaria. France furnishes a very hard and dark blue stone, which is but little used. In Canada stone of good quality is said to exist, as also in Missouri; but little is known of either. The Bavarian stone occurs in nearly horizontal layers. When these are of suitable quality and thickness (from two to five inches), they are squared and trimmed for exportation, the slabs varying in size from 6 × 8 to 40 × 60 inches. Two qualities are recognized: the yellow, and the blue or gray (though the difference in color is not much). The latter are harder and more generally serviceable, and cost ten to fifteen per cent more than the yellow.

Lithographic stone is a very homogeneous substance, free from sand or grit, and possessed also of strength sufficient to stand the wear and tear of the press. Besides carbonate of lime, it contains small quantities of magnesia and alumina, and traces of silica and iron. Its serviceableness for lithographic purposes depends chiefly upon its chemical constitution, in which respect it may be regarded as carbonate of lime only.

In this country, lithographic stones are sold by the pound, and the ratio increases rapidly with the size, varying from five to twenty-five cents. Zinc plates are used successfully as a substitute for stone, but they are by no means so generally useful. See LITHOGRAPHY and ZINCOGRAPHY. See also list of processes under FINE ARTS; ENGRAVING; 'GRAPH.

Lith'o-graph'ic Var'nish. An oily varnish used for the manufacture of lithographic ink, and by printers for thinning the same. It is made by heating linseed-oil very strongly in a suitable pan, and finally setting fire to it. When sufficiently changed in its nature, and sufficiently concentrated, the flame is extinguished by a cover, and the varnish let cool. The changes which take place during this treatment of the oil are not well understood. All the older recipes insist on the introduction of several slices of stale bread, and some peeled onions, into the oil when it gets hot. Their effect has been variously stated; but, beyond a great commotion and consequent exposure of the surface to the air, their beneficial action is more than problematical. When the oil has become hot enough to take fire, it is let burn under proper control, by which treatment a considerable diminution of its bulk is caused and an increase of its viscidity. The longer it burns the stiffer and more sticky it becomes, drawing out into threads between the finger and thumb. In this respect, there are three or four grades known to the trade, as Nos. 1, 2, 3, 4.

Lithographic varnish is not to be confounded with *boiled linseed-oil*, in the preparation of which oxide of lead is used. It retains enough of the greasy character to impart to the ink the qualities requisite for lithographic printing, but not enough to smear the stone or grease the printing-paper. It may tend to elucidate the changes which fatty bodies undergo when strongly heated and burned, if it is remembered that previous to combustion the oxygen of the air comes in contact with the hot surface; but that after the fused contents of a pan are covered with a flame, there can be no more oxidizing action, only a species of concentration or elimination of the more volatile constituents. See LITHOGRAPHY and LITHOGRAPHIC INK.

Li-thog'ra-phy. The process of engraving or drawing on stone, in such a way as to produce a surface from which printed copies can be multiplied in the press.

This great art, now an all-important industry throughout the world, has come into existence and attained its wonderful development within the present century. Until the discovery of lithography by Alois Senefelder, only two methods of printing were known and practiced: that from engraved metallic plates, and that from raised type or wooden blocks. Both of these were essentially mechanical in their nature, mechanical means were used to produce the engraved surfaces, and in printing, the simple adhesiveness of the ink was the one essential condition.

Senefelder discovered and developed to perfection a totally new method, in which the chemical constitution of the materials employed plays a vital part. The history of this invention, which occupied him three or four years, viz. from 1796 to about 1800, is interesting and instructive, but too lengthy for our space. It will be found fully given in his own work upon this subject, which has been translated into English.

The invention was the result of earnest, persistent, and highly intelligent work, tending towards a distinct object which Senefelder kept all the time before his mind, namely, the discovery of a new printing process which would adapt itself to his wants as an author. Much has been said by writers anxious to glorify the mere circumstance at the cost of the mind which grasps and utilizes it, of an accident which helped this great inventor on his way; but it will be found to have had no direct bearing on lithography, which was not invented until three years later, and that the credit of possessing creative genius of the highest order is Senefelder's indisputable right.

Almost the only stone suitable for lithographic work is a compact, sedimentary limestone of a yellowish or bluish-gray color, which comes from the now celebrated Solenhofen quarries in Bavaria. Such stratified slabs of stone as separate naturally into layers of from two to five inches in thickness are fit for lithographic use. They are trimmed on the edges so as to give them a rectangular form, are ground by moving one upon another, with sand and water between, and finally polished with pumice-stone. See LITHOGRAPHIC STONE.

Upon such a surface the artist produces the design to be printed from. This is done by one of four distinct methods: —

1. He draws it with a fluid, watery ink.
2. With a solid crayon.
3. He obtains it by transfer from an inky design produced on paper by various means.
4. He engraves it on a prepared stone.

1. In the first case, the lithographer uses an *ink* which, though it contains other substances, may be regarded as consisting essentially of a soluble soap (stearate or oleate of soda or potash) colored with lampblack sufficient to render it visible upon the gray surface of the stone. (See LITHOGRAPHIC INK.) The design is drawn with a watery solution of such an ink, using a pen or fine hair-pencil, exactly as it is required to appear when printed, and left to dry upon the clean stone. Such a drawing cannot be printed from until subjected to an *etching* process, the object of which is not to elevate or depress the work, but to act upon it chemically. The application of an exceedingly weak acid (nitric or hydrochloric) over the whole surface does not wash away or blur the image as water would; it decomposes the soap contained in the ink, combining with its alkali, and sets free, in intimate contact with the particles of carbonate of lime, of which the stone consists, the insoluble fatty acids contained in the soap. As far as the design is concerned, it is now fit for printing; that is, it would take printing-ink from the roller, but the other parts of the stone would not remain clean. To enable them to do so, the whole surface is flooded over with a solution of gum-arabic in water, the action of which is to incapacitate the clean places for receiving grease of any kind while wet. After a few minutes the excess of gum is washed away, the stone is dried, and placed in the hands of the printer. In appearance no change has taken place; the acid, although it necessarily dissolves part of the stone, does so to an imperceptible extent.

It should be remarked here, that at the present day the practice of applying the dilute acid and gum at the same time is almost invariably followed. The results, in both cases, are identical, but the older

method is described above, as better calculated to segregate the changes which take place.

The operation of printing may now be proceeded with. For this purpose the workman places the stone in the press, and adjusts the pressure. He then carefully washes off, with a sponge and abundance of clean water, any excess of gum, and while still wet he *washes out* the remains of the drawing with turpentine, in which it is soluble, using a piece of rag to rub the surface with. This procedure would smear the whole stone and utterly ruin the work, were it not for the protective action of the gum. When wiped clean, the surface at first glance appears to be perfectly blank; but a closer inspection shows the work as a *white* design, *in* the face of the stone.

The printer now passes the roller, charged with printing-ink, to and fro over the stone, which is still damp. The white image instantly takes the greasy ink, and holds it with a strong affinity. (See LITHOGRAPHIC INK.) The film first held by its adhesion accumulates more from the roller, and so on till the workman thinks the design is sufficiently *rolled up*. During this operation the rest of the stone has been kept damp; it will be found to have taken no ink from the roller. A sheet of printing-paper is next laid down upon it, the tympan is closed, and the stone *pulled through*. When again released, and the sheet lifted, the ink will be found to have divided itself between the stone and the paper. In this way lithographic impressions are *pulled;* the operations of *damping*, *rolling in*, and *printing* following each other in constant succession. Should the stone get dry, its surface will immediately take ink indiscriminately; but will part with it on being damped again, if the rolling be continued, without injury to the work. Only after *washing out* with turpentine does the *true white lithographic picture in* the stone become visible, its affinity for the black printing-ink causing it to remain covered all the time.

Such are the facts, without theory, upon which Senefelder's invention is based, and such the phenomena with which every good lithographer ought to be familiar. They repeat themselves, in modified form, in the other three methods, which it will not be necessary to describe at such length. The probable scientific explanation — though it involves the assumption of chemical reactions which many would dispute, and which are by no means demonstrated — is, that it is not simply a greasing of the particles of limestone which enables them to take ink and resist water while thousands of impressions are printing; but the formation of an actual chemical compound, more or less definite in its constitution. In fact, there are many reasons for believing that at the moment when the mineral acid sets the fatty and resinous acids free, they combine with the lime, displacing the carbonic acid, and forming insoluble lime soaps. In like manner it must also be assumed that the gum enters into a more or less perfect union with the substance of the stone, depositing at least an insoluble coating on the particles, which no amount of washing, or even continuous rubbing, can remove; and through which, though infinitely thin, no fatty matter can penetrate. Whatever the nature of this union may be, it is quite as essential to the successful prosecution of lithographic printing, as that produced by the fatty and resinous constituents of the ink, although the vital importance of the function performed by the gum has been almost universally ignored by the few persons who have written on the subject of lithography. It is also highly probable that the change which the gum effects is facilitated and perfected by the slight solvent action of the weak mineral acid on the stone, in consequence of which its surface is rendered chemically clean.

It will be readily understood that want of space, and the chemical character of the subject, make it inexpedient to do more than simply sketch out the above theory, without advancing arguments in its favor.

2. In the second method which the lithographic artist employs to produce his design, he avails himself of the lithographic *crayon* on a *grained* stone, — a stone the surface of which is evenly roughened by grinding it in a peculiar manner with very sharp and even sand. The crayon is composed of soap, wax, tallow, and sometimes resinous substances with lampblack, and it is used on stone as an ordinary chalk is on rough paper. In the hands of an experienced and capable artist, this modification of the lithographic art offers many advantages; great freedom in execution with delicacy in the lighter shades, as well as vigor, depth, and transparency in the shadows. To accomplish these results, genuine artistic capacity is of more importance than technical training; lithography differing essentially in this respect from the arts of copperplate and wood engraving. The drawing being finished exactly as it is to appear on paper when printed, the stone is acidulated or etched in the manner above explained as applicable to ink employed in the liquid state, and the result is the formation of the same white lithographic picture, capable of taking printing-ink. The effect of the grain of the stone, in giving character to this method, does not require lengthy explanation. It prevents the continuity of the stroke, the particles of chalk closing in round the asperities, and producing deeper tones in proportion as the artist leans more heavily, but rarely or never bridging them over so as to produce perfect blackness, with opacity as a consequence.

A modification of crayon-drawing is the production of *rubbed tints* on stone, chiefly for chromolithographic work. The material used as crayon for this purpose is not cast into cylindrical sticks, but applied in larger masses. It is rubbed upon the grained surface pretty freely, and then rubbed off or distributed in accordance with the lights and shades of the design, a small piece of woolen cloth or a *stump* being used for this purpose; afterwards the stone is strongly etched. For soft, undulating surfaces rubbed tints are unsurpassed, and their use does not hinder that of crayon for portions of the work requiring more force and detail than can be readily given by *rubbing*. See LITHOGRAPHIC CRAYON.

3. The third lithographic method is by *transfer*. Of this there are several varieties, but they all resemble each other in the fact that the work is not drawn or engraved upon the stone direct, but is placed there in a completed condition from some source furnishing it, and that paper is invariably used at the medium, by the intervention of which it is carried over.

Autographic transferring, in this country, is almost solely confined to the reproduction of manuscript matter for business purposes. The writing is often done on ordinary, well-sized writing-paper; but better on paper prepared with a thin coating of gelatine, flour-paste, or starch, which may be colored by gamboge. Such a sheet, after being written on, is damped (sometimes with an exceedingly weak acid) and then laid face downward on a clean stone in the press, and *pulled through*. If the paper was well prepared, it will adhere to the stone. It is then damped on the back, and pressure again applied. When, at last, the sheet is carefully lifted, the ink will be left behind in contact with the stone. It is

then etched with acidulated gum-water in the usual way, and then printed.

All transferring is done in this manner, save that the ink differs according to the nature of the work.

Autographic transfers, of a very superior character, are quite common in Great Britain. Much of the map-work, ornamental designs, and lettering is done on transfer-paper by persons who make this branch of the art a specialty.

Transferring from stone to stone constitutes at the present day one of the most important and difficult of the processes practiced by the lithographer, and every large establishment has two or three, or more, men who do nothing else.

When a design has been engraved or drawn upon stone — often at considerable expense — it is almost the rule in this country not to print from it direct. It is found safer, quicker, and more economical to preserve the original stone carefully, making as many transfers for the press as the size of the work and that of the edition will warrant. In this way small work, such as labels, show-cards, etc., can be multiplied upon a stone, and the expense of printing proportionately reduced, with a facility which often gives lithography the advantage over typography, even in cost. Very valuable original stones also are saved from the wear and tear of the press, and from accidents; and the artist's work, in place of furnishing but two or three thousand impressions, may yield indirectly many times that number. It is true a transfer is not always equal to the original in quality, but the difference is very slight, and such work is for many purposes quite satisfactory.

Impressions for transfer from stone to stone are pulled or printed very carefully on India proof-paper with a starched surface; but an ink differing from printing-ink is used, the constitution of which makes it very effective when transferred to the clean stone. See LITHOGRAPHIC INK.

Transfers from engraved stones and plates are pulled in the same way as ordinary impressions from such are printed (an operation to be presently described), but with stiff transfer-ink.

Photo-lithographic transfers will be found described under PHOTO-LITHOGRAPHY.

4. Engraving on stone — the fourth subdivision of the art — is essentially different from the preceding methods of producing a printing-surface. It is very largely practiced, however, especially in the United States, and is of much importance.

For this purpose, after a stone of suitable size is polished, its whole surface is etched or prepared with gum-water and an exceedingly dilute acid, and its face is then colored black with a trace of lampblack, or red with a little powdered red chalk, and let dry. The coloration is simply to enable the engraver to see his work as it progresses. Upon this surface the design is now engraved, or rather scratched; sharp-pointed steel needles and the diamond being almost the only tools used. When the design is finished, oil is poured over the whole, and some time is allowed for its absorption by the stone where the needle has laid it bare. The coloring matter, and any excess of gum upon the surface, is next washed off, and ink is rubbed into the lines with a *tampon* or pad, made of some folds of woolen cloth fastened to the face of a small piece of flat wood. As the treatment with gum protects the rest of the stone, it will remain clean as long as damp. If an impression be now pulled, the sheet will lift the ink out of the lines, which are very shallow, as in copperplate printing. From the foregoing it will be seen that printing from an engraved stone is an interesting and complex operation. The ink is held not only by the peculiar nature of the lithographic picture, which forms the bottom of the lines, but also mechanically by reason of their depression and depth; and the rest of the surface is clean, not because it is wiped off mechanically as in copperplate printing, but because it is damp and does not take ink. Lithographic engraving, however, differs considerably from engraving on copper or steel. As it is done in a friable substance with the needle, the boundaries of the lines never attain the smoothness and clearness which are given by the graver, though the approximation is much closer than would be supposed possible, the dexterous use of the diamond giving wonderful perfection in this respect. The ponderousness of the stones, and the *drawing* character of the method, take also from the freedom and sweep which the experienced copperplate engraver imparts so readily to his work; lastly, the depth of the line cannot be proportioned to its width, as is the case on steel or copper. At the present day very little printing is done from engraved stones, — almost none in this country, — but they are constantly used, nevertheless, in consequence of the great facility with which transfers of the finest and most delicate designs can be made from them, and from them only.

Printing from engraved work is slow, and therefore costly, but after transfer it is done with the roller and without unusual expense. In this way it is possible to supply work (so fine that it can only be produced with the needle and diamond) at a very moderate cost.

A most striking elaboration of this system is to be found in the commercial lithography of the United States, especially bonds, checks, certificates of stocks, etc., which, in redundancy of ornament (excellent as to quality), are not equalled by that of any other country. The vignettes, borders, etc., for such documents are all transferred from separate engraved stones, which are retained on hand in great variety as an important part of the lithographer's stock in trade, and from them any particular design can be compiled or built up and transferred to a smooth stone.

Analogous to lithographic engraving is the process of etching on stone, so as to produce a similar result. This is sometimes used very successfully on ruled shades and tints. For this purpose, the stone is protected by a shellac ground, which is cut through by the steel-point or diamond, generally the latter. A wall of wax is then raised round the edge of the stone, and dilute nitric or hydrochloric acid poured on. When bitten deep enough, the lines are filled with thick lithographic writing-ink, and let dry. The ground is then removed and the surface etched strongly with acid and gum. This modification is generally used in combination with engraving to produce certain effects.

In addition to the foregoing four great subdivisions of the lithographic art, various expedients are used to produce certain results which hardly deserve mention here. One exception, perhaps, is to be found in a method, very commonly followed, of obtaining graduated tints for color-printing. For this purpose, a solution of asphalt and crayon in turpentine is applied to a grain stone, let dry, and then scraped more or less with a scraper or knife, according to the tint required. The stone is then etched, washed out, and printed. This method is now superseded in many establishments by the rubbed tint already described.

Chromo-lithography is doubtless the highest de-

velopment of the lithographic art. For it all the foregoing methods are put in requisition, but it does not itself constitute an essentially distinct method in a technical sense. In the imitation and reproduction of oil and water-color paintings, much knowledge and experience not possessed by the ordinary lithographer are required; still the novel and difficult part of the art of making first-class chromos lies in the appreciation and selection of colors, their judicious superimposing and blending, and above all things in a cultivated estimation of the true value of a picture and of pictorial effects generally. See CHROMO-LITHOGRAPH.

Senefelder died in 1834. Every phase of the lithographic art described in the preceding sketch was indicated, originated, or practiced by him. Even chromo-lithography was suggested and anticipated by him. The development and perfection of the present day, in every branch of his great invention, would gratify and astonish him infinitely; he would gaze in amazement at the lithographic power-press, printing thousands of sheets daily; and his philanthropic mind would be lost in admiration at the sight of a chromo, which he would confound with the original painting, and which his art has placed within the reach of every one. All this he would readily comprehend; *photo*-lithography alone would be to him a mystery and a revelation. — *Contributed to this work by Mr. J. W. Osborne.*

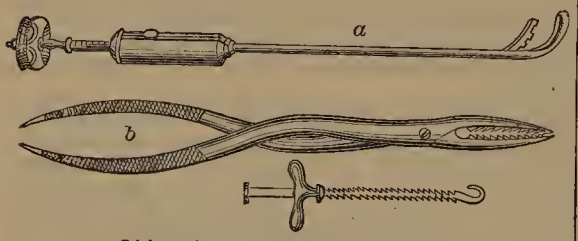
Lith'o-labe. (*Surgical.*) An instrument for grasping a stone in the bladder, and holding it while it is being acted upon by a lithotritic instrument. The *lithoprione* is a form of litholabe.

Lith'o-lyte. (*Surgical.*) A form of catheter for conveying solvents of calculi into the bladder.

Lith'on-trip'tor. An instrument for crushing the stone in the bladder into minute fragments, that they may pass out with the urine.

The instrument *a* is made of two halves, one sliding within the other, and is of the size and shape of an ordinary catheter when closed. It is introduced into the bladder by the urethra; then, by means of a screw or rack and pinion worked on the outer extremity, the movable part is made to slide back within the bladder, now forming two jaws by which the stone is seized; by turning the screw or handle, the blade is propelled onward again by short jerks, thus breaking the stone into fragments so minute that they may pass the urethra.

Fig. 2978.



Lithontriptor and Lithotomy-Forceps.

This is followed by the use of the lithotriptic instrument, the *evacuating catheter* or *double-current catheter*, which is a catheter of moderate size, having a wall along its center, dividing it into two canals. By means of the upper one the bladder is filled with tepid water, which finds its exit through the lower one, carrying with it all particles of stone remaining after the operation of lithotrity.

The temple of Serapis in Alexandria was used as a hospital in the time of the Ptolemies, and here were performed operations in lithotomy, crushing the stone, reducing dislocations, etc.

Ammenius of Alexandria, the first century B. C., proposed and performed the operation of lithotrity, or breaking a calculus in the bladder, when too large for extraction by lithotomy. The Romans seem to have been much subject to the stone in the bladder.

The lithotritor of Celsus (first century A. D.) was a hook inserted behind the stone while it was cleft by the end of a blunt instrument, struck by a hammer. This instrument was similar to some of the modern.

Lith'o-pho-tog'ra-phy. A process by which a photographic picture is developed on stone, so as to admit of impressions being taken therefrom. See PHOTO-LITHOGRAPHY.

Li-thor'i-neur. An instrument invented by Meirieu and Tanchou for filing down a calculus in the bladder.

Lith'o-tint. A process of drawing upon stone, in which the ink is applied to the stone by a camel's-hair pencil.

Lith'o-tome. (*Surgical.*) A bistoury or scalpel for making the incision in lithotomy. This knife is of various sizes and shapes, blunt, probe, or sharp pointed. It is inserted through the groove of the lithotomy-*staff*, through a small opening previously made in the urethra, and carried along into the bladder, making an opening just large enough to allow the extraction of the stone by means of the forceps. The *gorget*, *bisector*, and *bistouri caché* are varieties of *lithotomes*. Hippocrates, d. 357 B. C., treats of the operation of lithotomy, which seems in his time to have been practiced as a specialty by certain chirurgeons. Five methods of operating are enumerated by Dunglison, in some cases requiring special instruments. As it is the neck or body of the bladder that is cut, the instrument might more properly be called a *cystotome*.

Li-thot'o-mé-cache. (*Surgical.*) An instrument used in lithotomy. It is introduced with blades concealed in a sheath, from which they are protruded, by pressing upon a lever, on reaching the place of operation. The incision is made by withdrawing the instrument. It is made single or double bladed. Called also a *bistouri-caché*.

This instrument is specifically recommended by Sabatier, 1797, in an article read before the National Institute of France, October 6, 1797.

Li-thot'o-my-bi-sect'or. (*Surgical.*) An instrument for making the bilateral incisions in lithotomy.

Li-thot'o-my-for'ceps. An instrument (*b*, Fig. 2978) for extracting stone from the bladder through the opening previously made by lithotomy. Its blades are concave, with rasp teeth cut in to take a firm hold on the stone, the outer surface well rounded to admit of easy introduction, with crossed shanks so that the blades may be fully opened within the bladder without expanding the wound.

Li-thot'o-my-gor'get. (*Surgical.*) A lithotome with one or two concealed blades which are exposed by pressure when required.

Li-thot'o-my-scoop. (*Surgical.*) A small, spoon-like instrument for removing calculi or fragments of stone from the bladder, after the operation of lithotomy or lithontripsy.

Li-thot'o-my-search'er. (*Surgical.*) See LITHOTOMY-SOUND.

Li-thot'o-my-sound. (*Surgical.*) A steel, catheter-shaped instrument introduced into the bladder by the urethra. It indicates the presence of stone by a peculiar click when it comes in contact with it.

Li-thot'o-my-staff. (*Surgical.*) An instrument curved like a catheter and with a deep groove

on the convex side of its curved portion, introduced into the bladder by the urethra, for the purpose of guiding the cutting-instrument in lithotomy.

Lith'o-trip'tor. See LITHONTRIPTOR.

Lith'o-tri'ter. See LITHONTRIPTOR.

Lith'o-type. 1. A stereotype in which the surface is composed of gum-shellac, fine sand, and a little tar and linseed-oil.

2. A name signifying printing from stone. The lithographic design on the stone is deeply etched, giving a sufficient relief for the type-press.

Lit'mus. A coloring matter produced from the lichen *Rocella tinctoria*.

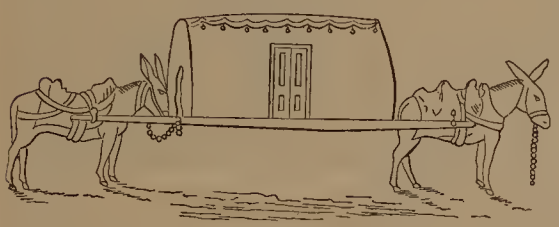
Li-tram'e-ter. An instrument for ascertaining the specific gravity of liquids, invented by Dr. Hare of Philadelphia.

It is founded upon the principle that, when columns of different liquids are elevated by the same pressure, their hights must be inversely as their gravities. It consists of two tubes, their lower ends open and submerged in two liquids whose specific gravity is to be compared, say one vessel of water and the other of an oil or spirit. The tubes connect above with a horizontal pipe, from which the air is exhausted by an air-pump. Atmospheric pressure causes the liquids to rise in the tubes to a hight according to their gravity.

Lit'ter. A *stretcher* with a bed, and in many cases a canopy; used, not as the stretcher ordinarily is, in emergency and haste, but provided for the use of the civil sick, during necessary transportation home or hospital-ward.

Another form of litter is adapted to be carried by two animals. This approaches or reaches the palan-

Fig. 2979.



Litter.

quin, and there is probably no absolute dividing-line between the two.

The litter (*lectica*) on which the body of Augustus was carried to the grave was made of ivory and gold, and covered with costly purple drapery worked with gold.

Stretchers were used in the Roman army to carry wounded officers.

The Asiatic litter was introduced into Greece, having four posts, canopy, and curtains. They were carried by four bearers, and used in traveling. When standing, it rested on four feet. The *lectica* of the Empire was closed with panels of *lapis specularis*, — talc. The poles were removable. It was a palanquin, carried on the shoulders of the bearers.

Companies were formed, and lecticæ were placed in public places for hire.

The lectica was adapted for a person lying down; the *sella*, or sedan-chair, for the sitting posture.

Lit'tress. A smooth kind of cartridge-paper, used in the manufacture of cards.

Live-ax'le. One communicating power; in contradistinction to a *dead* or *blind axle*.

Live-box. A cell in which living microscopic objects are confined for observation. It has a tubular piece with a glass top, upon which slips an upper ring having also a glass top. The object is confined between the glasses.

Live-gang. (*Saw.*) A gang-saw mill, so arranged as to cut through and through the logs without previous slabbing. The bark and wany edge are afterward removed from each board by a *double edger*. The lumber goes to market of the full width.

Live-head. (*Lathe.*) The *head-stock* of a lathe, which contains the *live-spindle*; in contradistinction to the *dead-head* or *tail-stock*, which contains the *dead-spindle*.

Live-mat'ter. (*Printing.*) Type in page or column ready for printing.

Liv'er of An'ti-mo-ny. A sulphuret of antimony and potassa.

Liv'er of Sul'phur. Fused sulphuret of potassa.

Live-spin'dle. (*Lathe.*) The rotating effective spindle in the *head-stock* of a lathe; in contradistinction to the *dead-spindle* in the *dead-head* or *tail-stock*.

Live-steam. (*Steam-engine.*) 1. Steam from the boiler at its full pressure; in contradistinction to *dead*-steam.

2. Steam from the boiler; in contradistinction to *exhaust-steam*.

Live-trap. A device for imprisoning living microscopic objects. It consists of three parallel glass slips; the middle one has a circular perforation forming the cell, while the other one constitutes the sides.

Lix-iv'i-al Salt. One obtained by leaching.

Lix-iv-i-a'tion. The process of separating a soluble from an insoluble material by a washing or filtering action. *Leaching*.

Lixiviation removes a soluble material, which is the valuable portion, as in discharging a certain amount of syrup from a bone-black filter, by passing water therethrough. The *leaching* of ashes is a familiar instance of lixiviation.

Elutriation is the separation of more soluble and comparatively useless portions from one less soluble, by allowing the latter to settle and decanting the supernatant liquor, as in the case of removing the saccharine and coloring matter from starch in the starch manufacture.

Liz'ard. 1. (*Nautical.*) *a.* A piece of rope having one or more legs with thimbles acting as *fair-leaders* or for other purposes.

b. The *top-gallant lizard* is a rope with one end hitched to a hole in the *royal-pole* and the other spliced round a thimble on the hauling part of the mast-rope. It keeps the mast from turning over when its head comes below the topmast crosstrees.

2. A crotch of timber or a forked limb, used as a sled to support a stone being hauled off a field. A *stone-boat*.

Li-ziere'. (*Fortification.*) A *berme*. A small coping or space between the foot of the parapet and the scarp.

Load. The amount of work done by an engine working up to its capacity. Not to be confounded with *duty*.

Load'er. A machine attached to a wagon, as a *hay-loader* or *stone-loader*. In the former case, it is an endless traveling apron on a truck, trailing behind the wagon and carrying up the hay collected by a rake. See HAY-LOADER.

Load'ing-fun'nel. One for charging mortars with loose powder.

Load'ing-ham'mer. One for loading rifles.

Load'stone. A natural magnet. An ore of iron; the protoxide and peroxide of iron in combination. See MAGNET.

Load Wa'ter-line. (*Nautical.*) The line of

flotation of a ship when she has her full cargo on board.

Loaf. 1. The conical mass of molded sugar.

2. A shaped mass of light bread in the dough state, or baked.

Loam. (*Founding.*) A mixture which essentially consists of sand and clay, the former largely predominating, with a certain quantity of horse-dung added, or some equivalent for the same, such as chopped straw, sawdust, cow-hair, etc. Beds of loam are sometimes found of nearly suitable composition, but it is more commonly made up by blending different sorts of sand, clay, etc., in a mill resembling a pug-mill. In molding, it is always used quite wet, like plaster, but is dried perfectly before pouring. Its characteristics must be plasticity while wet, strength and solidity when dry, perviousness to the *air* from the mold, and the power to resist the high temperature of the metal. It is employed for large work in both brass and iron, obviating the use of a pattern, as already explained. See MOLD.

Loam-beat'er. (*Founding.*) The rammer of a molder, used in compacting the loam around the pattern.

Loam-board. (*Founding.*) Cores which are struck up upon a spindle or barrel are supplied with loam from a board placed across the trestles on which the barrel revolves, which is hence called a *loam-board.* This is cut to the shape of the core. It is also used after the latter is dry, as a rest on which to place the tool (a very broad chisel with a short handle at each end) used to turn it down to the exact size and shape, before black-washing.

Loam-cake. A disk of loam which covers in the mold in *loam-work* casting, and which is perforated with holes for the entry of the metal and the escape of the air.

Loam-mold'ing. Making a mold by templets. See MOLDING.

Loam-plate. (*Founding.*) One of the flat cast-iron rings or plates used in loam-molding, upon which the nowel or the cope rests, as the case may be.

Loam-work. A method of making molds for large hollow castings, such as cisterns, tanks, steam-engine cylinders, and kettles of large size, etc.

Instead of making a pattern of the object, the *nowel* and *cope* are built up of bricks and covered with loam, which is shaped by a templet. The parts are afterward brought into the required juxtaposition in a pit, surrounded by packed sand, and then the metal is run in.

Lob'bing. (*Metallurgy.*) Breaking blocks of ore into pieces with the hammer, for assortment as to quality with such ores as copper, and for more effectual treatment in the preparatory roasting or calcining processes. Otherwise called *cobbing.*

Lobe-plate. A strong piece of cast-iron laid upon the keelson, etc., to support the parts of a marine steam-engine. A *sole-plate.* A *foundation-plate.*

Lo'cal. (*Telegraphy.*) The battery of a *local circuit.* The latter is one which includes only the apparatus in an office, and is closed by a relay.

Loch'a-ber-axe. The battle-axe of the Highlanders.

Lock. (Anglo-Saxon, *loc,* an inclosure or fastening.) 1. A device having a bolt moved by a key, and serving to secure a door, lid, or other object.

The ancients, though possessing many valuable arts and great skill, do not seem to have been successful in locks. Those of the Egyptians, Greeks, and Romans were clumsy contrivances. Denon has an engraving of an Egyptian lock of wood, which is similar to the one shown at *A,* Fig. 2980.

The locks used to the present day in Syria are much like those used over 2,000 years ago in Palestine and in Egypt. Thompson mentions that the steward of the Carmelite Convent, on Mt. Carmel, opened his magazine with a key as large as a club; reminding him of the passage, "And the key of the house of David will I lay upon his shoulder." — Isaiah xxii. 22.

The strongholds of the castles of Syria yet have enormous locks and keys. They are placed on the inside of the doors, and have a number of metallic wards which are adjusted by the pins on the key. A hole is cut through the door, and the hand and arm thrust through to insert the key. "My beloved put in his hand by the hole of the door, and my bowels were moved for him." (Canticles v. 4.) That is the way "the beloved" let himself into the chamber.

In the Book of Judges, chapter iii. verses 23 – 25, it is stated that Ehud, going forth, locked the doors, and his servants took a key and opened them. This was 1336 B. C., and is the first mention of a key which could be taken out of the lock.

A, Fig. 2980, shows one of these Oriental locks. The following is the description given in Eton's "Survey of the Turkish Empire," published towards the close of the last century. It will answer as well for the present time: —

"The key goes into the back part of the bolt, and is composed of a square stick with five or six iron or wooden pins, about half an inch long, towards the end of it, placed at irregular distances, and answering to holes in the upper part of the bolt, which is pierced with a square hole to receive the key. The key, being put in as far as it will go, is then lifted up; and the pins, entering the corresponding holes, raise other pins which had dropped into these holes from the part of the lock immediately above, and which have heads to prevent them falling lower than is necessary. The bolt, being thus freed from the upper pins, is drawn back by means of the key; the key is then lowered, and may be drawn out of the bolt. To lock it again, the bolt is only pushed in, and the upper pins fall into the holes in the bolt by their own weight."

Locks of this kind are supposed to have been exchanged by the Phœnician navigators with the people of Cornwall for tin, and locks of this pattern, but home-made, still exist in that queer old prong of Britain.

Occasional notices are found among the Greek and Roman writers of the keys of their times; as when Aratus compares the constellation of Cassiopeia to a Roman key, "having a curved stem" and a handle "shaped like the south stars" of the group. Ariston also refers to their "deeply bent" stems, and Eustathius compares them to sickles; and indeed some were so large that they might fairly be carried over the shoulders, as described by Callimachus in his "Hymn to Ceres," where he represents the priestess of Nicippe carrying her key in that manner.

Homer's allusion to the lock on the wardrobe of Penelope is thus rendered by Pope: —

> "A brazen key she held, the handle turned,
> With steel and polished ivory adorned.
> The bolt, obedient to the silken string,
> Forsakes the staple as she pulls the ring;
> The wards, respondent to the key, turn round,
> The bars fly back, the flying valves resound;
> Loud as a bull makes hill and valley ring,
> So roared the lock when it released the spring."

It is said that locks with sliders and tumblers have for centuries been made in China.

Tradition says that locks were made in England in the reign of Alfred, but it was not till the fourteenth century that the craft was recognized as a

distinct one. In the reign of Elizabeth, locks with bells or chimes attached were so constructed as to ring an alarm or play a tune when tampered with. The medieval locks were often highly ornamented and artistic pieces of workmanship, constituting quite an important part of the church-door or cabinet to which they were attached. A number yet survive on the cathedrals and churches of Europe, and on the plate and muniment chests of the old families.

The letter-lock is a Dutch invention, but is ascribed, in the "Memorabilia" of Vanhagen von Ense, written about 1650, to Regnier, Director of the Musée d'Artillerie at Paris. Regnier's locks were much esteemed, and the courier's dispatch-boxes were fastened with them. They are, however, alluded to in Beaumont and Fletcher's "The Noble Gentleman," printed in 1615. See LETTER-LOCK, p. 1292. Carew, in some verses written five years later, has this reference: —

> "As doeth a lock that goes
> With letters; for, till every one be known,
> The lock 's as fast as though you had found none."

The letters of the alphabet were engraved on four parallel revolving rings, which by prearrangement on the part of the owner were made to spell a certain word, or number of words, before the lock could be opened.

A French treatise, *L'Art de Serrurier*, published in 1767, contains many examples of the locks of that and former periods. It appears that, though the art had advanced as far as the invention of the single tumbler, yet the main dependence was placed on the complexity of the wards. Multiple bolts, shot simultaneously by a single key, were much in vogue. One lock, figuring in this work as attached to a large coffer or chest, has as many as twelve of these bolts.

The simplest modern form of lock is the common spring-lock, the interior arrangement of which is shown at *B*. In the cut, the bolt is represented half shot. At *a a* are two notches on the under side of the bolt, connected by a curved part; *b* is the back spring, which becomes compressed by the passage of the curve through a limited aperture in the rim *c c* of the lock. When the bolt is wholly withdrawn, one of the notches *a* rests upon the rim *c c*, and the force with which the notch falls into this position, urged by the spring *b*, gives rise to the snapping or clicking noise. When the bolt is wholly shot, the other notch rests in like manner upon the edge of the aperture in the rim.

Wards, or *wheels*, were among the most important improvements in locks, and when sufficiently complicated were considered, especially when the lock was provided with numerous and strong bolts, as affording nearly perfect security.

Wards, shown at *B* and *C*, are pieces of metal having a circular curvature, and are affixed to the interior of the lock. They may be in cross-section of any shape, affording sufficient strength to resist the usual wear and tear occasioned by the motion of the key, which is very slight. They fit into clefts or grooves in the key, which turns around upon them, and prevent the lock from being opened except by its own proper key, or by a key so constructed as to avoid them altogether.

G is a ward-lock key and its keyhole. The various parts are, —

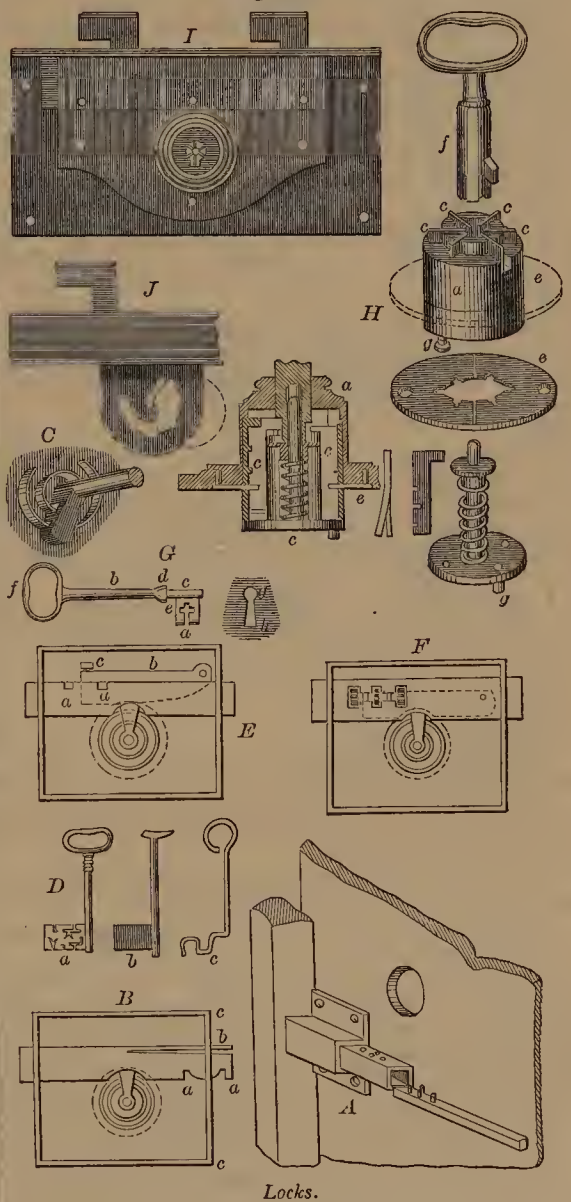
a, the *main*-ward, or *bridge*-ward.
b, *stem*, or *body*.
c, *pin*.
d, *collar*.
c, *bit*, or *web*.
f, *bow*.
g, *eye*.
h, *slot*.

D shows the manner of opening a warded lock by means of a false key. *a* is the true key, the wards of which are somewhat complex. An instrument *b*, covered with wax or soap on one side, is inserted in the keyhole and turned, receiving a perfect impression of the wards. A piece of wire *c* is then bent into such a shape as to avoid contact with these when turned in the lock, withdrawing the bolt with as much facility as the proper key would do.

This is a *skeleton*-key. A *master*-key is similar in principle, being so constructed as to avoid the wards of a set of locks. Such keys are adapted to locks having wards of the same general form.

The period of the invention of tumbler-locks (*E*) is unknown. Some elaborate examples are exhibited

Fig. 2980.



Locks.

in the French treatise before referred to, published in 1767.

The *tumbler* is a lever or latch which falls into a notch of the bolt, and prevents it from being shot until the tumbler has been raised or released by the action of the key. A simple form is shown at *E*. The bolt has two square notches *a a* in its upper edge. Behind the bolt is the tumbler *b*, pivoted at one end, and having a projecting stump *c* at the other, which, in either position, locked or unlocked,

falls into one of the notches of the bolt. The tumbler must first be lifted by the key, releasing the stump from the notch in the bolt before the key can act on the latter to turn it either way.

Barron's tumbler-lock was patented in 1778. Its principle consisted in an arrangement "to allow a stump on the tumbler to pass through an opening in the bolt, or a stump on the bolt to pass through an opening in the tumbler."

The former arrangement is shown at *F*. This lock has two tumblers of unequal width, each having a stump or stud which, when the lock is in either a locked or unlocked position, rests in one of the notches represented in the bottom of the gating of the bolt. The web of the key has two unequal steps which, when the key is turned in the lock, elevate the tumblers equally and to a sufficient hight to lift the stumps clear of the lower notches in the bolt and bring them exactly on a level with the gating or slot in the bolt, permitting the latter to slide freely; whereas, if an improper key be used, they will be either lifted too high or too low, so that it cannot pass.

The patents granted for locks, both in England and this country, since Barron's time, have been very numerous. Brahmah's, patented in England, 1784, is shown at *H*. It has a central barrel *a*, having grooves in which are a number of sliders *c c*, whose ends rest against the spring. Each of these is notched at a different part of its length, so that they must be unequally depressed before the plate *c* can enter all the notches simultaneously, and allow the barrel *a* to turn so as to actuate the bolt. This is effected by a stud *g* working in the slot on the bolt shown at *J*. The sliders are provided with false notches to increase the difficulty which a burglar would experience in finding the position of the true ones. The key *f* has longitudinal slots corresponding in length to the distance which each slider must be depressed.

I is an exterior view of the lock, and *J* shows the form of the bolt and the manner in which the rotation of the barrel is made effective in throwing the bolt.

The patent of Mitchell and Lawton, 1815, embraced, among other devices, a revolving curtain for closing the keyhole.

A detector which indicated if any of the tumblers had been overlifted was patented by Ruxton in 1816.

In the same year, Kemp devised a lock whose sliders were operated by a set of small concentric tubes in the barrel of the key.

Paper secured over the keyhole to indicate tampering was patented by Gottleib, 1829.

At the present day, the aid of photography has been called into requisition as a detector.

Two photographs are made from an irregular pattern, one of which is placed over the keyhole, and the other is retained. The American Seal-Lock Company employs sheets of variegated glass, cut into strips, for this purpose. Access to the keyhole can only be obtained by breaking the glass, which of course cannot be replaced. See SEAL-LOCK.

Chubb's lock, 1818, has six or more tumblers turning on a pin common to all. Each of these must be lifted to a different hight before a stud on the bolt can pass through a continuous aperture formed by a slot in each tumbler when all are in their proper position. Should either of the tumblers be overlifted by the introduction of a false key, it is held in that position by a spring, thus indicating that the lock has been tampered with.

In Newell's American lock (exhibited in England in 1851) the bits are interchangeable on the stem of the key, so that an indefinite number of combinations may be formed, each of which so alters the relative position of the tumblers at the moment of locking that they can only be brought into position to allow the bolt to be withdrawn by the same arrangement of the bits. There are three sets of bits, the two nearest the keyhole falling to a common level when the key is withdrawn, while those of the third, which are inaccessible to the "feeling" devices of the burglar, remain at the different hights to which they were lifted by the key through the medium of the other two. See PERMUTATION-LOCK.

It has been proposed to construct locks with clock-work attachments, so that they cannot be opened, even with their proper key, until a regulated interval of time has elapsed. Mr. Rutherford of Jedburg, Scotland, patented a lock of this description in 1831.

A circular stop-plate is placed against the end of the bolt of the lock, and so adjusted that the bolt cannot be withdrawn until a particular notch in the rim of the circular plate is, by means of clock-work, brought opposite the end of the bolt.

Locks having pins or pipe-shafts fitting in the pipe or barrel of a key can only be opened from one side, but those adapted for keys with a solid stem can be opened from either side. In the latter case, only one half the key acts at once.

The variety, both in the form and nomenclature of locks, is very great. Not all of the English trade terms for locks obtain with us. The following is a summary; some of the distinctions are evident, others will be explained: —

A *bolt-lock* is one the bolt of which can only be driven or withdrawn by the action of a key.

A *latch-lock* can be opened by a knob on the inside, but requires the use of a key on the outside.

In-door and *out-door* locks, on the respective sides of a door.

Door-locks are known as *iron-rim*, *brass-case*, or *mortise*, according to the quality or mode of fitting. The *draw-back* has a bolt capable of three positions, *locked*, *latched*, or *open*. The *spring-stock* is a wooden door-lock of inferior quality.

The *dead-lock* or *closet-lock* has a single bolt.

The *two-bolt* has a latch and bolt.

The *three-bolt* has the addition of an interior bolt, not operatable from the outside by any means.

The *knob-lock* and *ring-lock* are so named from the forms of their handles.

The *right-hand* and *left-hand* locks are for door to swing to the right or to the left.

A *dormant-lock* is one having a bolt that will not close of itself.

A *spring-lock* is one whose bolt is protracted by a spring.

A *rim-lock* is named from its shape.

Ward-locks are so called from having *wards* corresponding to clefts in the key, into which they must enter before the key can be turned. They are known as *one-ward*, *two-ward*, etc., according to number; the round wards being sometimes called *wheels*, as *one-wheel*, *two-wheel*. The shape of the ward sometimes gives a name, as L-*ward*, T-*ward*, Z-*ward*. If the ward be cast solid instead of being made of a bent strip, the lock is termed *solid-ward*.

A lock without wards is a *plain-lock*.

Straight-locks have a plate screwed flat against the woodwork; *cut-locks* are inserted into the woodwork, so as to lie flush therewith. *Mortise-locks* are slipped into a mortise cut into the *edge* of the door.

Tumbler-locks have one or more pivoted pieces, called *tumblers*, provided with a lug or dog fitting a notch in the bolt, from which the dog must be released before the bolt can be thrown.

The *letter*, *puzzle*, *permutation*, or *combination* lock has usually a series of notched rings, which must be

turned until all the notches are in line in order to enter or withdraw the bolt.

Wheel-locks are those in which one or more wheels form a part of the interior mechanism.

Detector, *protector*, *paranoptic*, *vibrating-guard*, *compound-lever*, *defiance*, *duplex*, *detent*, *holdfast*, *drill-proof*, are among the names given by inventors to various descriptions of patented locks.

The *stock-lock* is an outside wooden lock for stables, gates, etc.

D-locks and P-locks are gate-locks of forms resembling those letters.

Many locks are known by their adaptation to specific uses; as, *cabinet*, *cupboard*, *bookcase*, *desk*, *portable desk*, *table*, *drawer*, *box*, *cuddy*, *chest*, *carpet-bag*, *valise*, *trunk*, etc., locks. See list, p. 1342.

2. (*Hydraulic Engineering.*) *a*. An inclosure in a canal between gates, where boats are raised and lowered. See CANAL.

The parts of a canal-lock are, —

The *head-gate* and *tail-gate*, which, with the *side-walls*, inclose the lock-*chamber*. They are made of *framing* with *leaf-planking* nailed and bolted thereto.

The *clap-sill* or *miter-sill*, with two *branches*, is the framing against which the lower edge of the gate shuts.

The *hollow-quoin* is the recess in the masonry occupied by the *heel-post* of the gate.

The *head-bay* or *head-crown* is the canal above the lock.

The *tail-bay* or *aft-bay*, below the lock-chamber.

The *lift* is the amount of fall overcome by the lock.

The *lift-wall* is the wall at the foot of the head-gate.

A canal-lock is a device by which boats are passed from one level to another. It consists of a basin between the levels, having a pair of gates at each end communicating with the respective level. Fig. 2981 shows a vertical, longitudinal section *a*, a plan *b*, and views of the upper and lower gate *c d*.

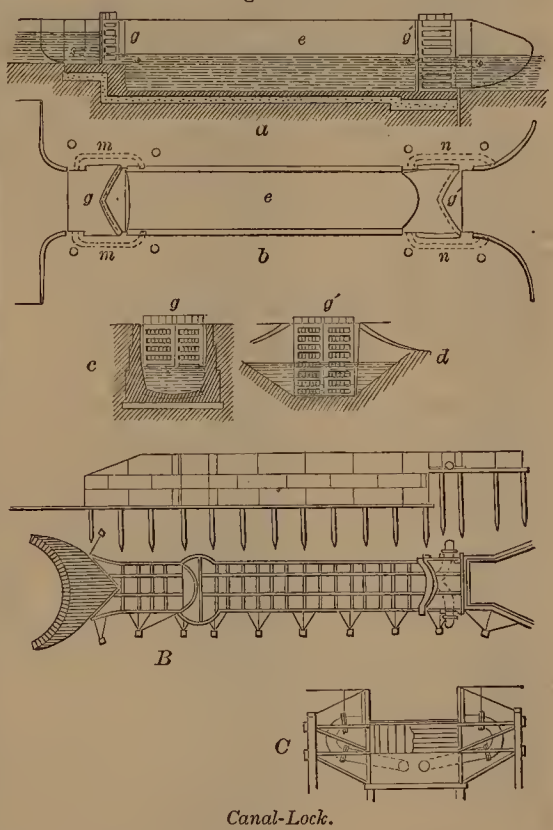
e is the lock-chamber; the floor is called the *invert*, and is lined with masonry. The floor of the upper end is even with the upper level, and the lower floor with the lower level. The gates are shown at *g g'*; they turn upon their hingeing ends; when shut, they close against each other, presenting an angle up hill against the force of the water. When a boat is to ascend, the lower gates are opened, the boat floated into the chamber, and the gates closed. Water is then allowed to pass by underground conduits *m m* to the chamber, until it is even with the water of the upper level; the upper gates are then opened and the boat floated out. In descending, the boat is floated into the full chamber, the upper gates closed; the water in the chamber allowed to pass from the latter by the conduits *n n* to the lower level, until the level of the water on each side of the lower gates is even, when they are opened and the boat floated out.

The Ellesmere and Chester Canal, England, crosses a quicksand in Cheshire, at which place cast-iron locks and lock-gates were made. The locks (*B C*) rise 17 feet, are founded upon piles, and formed of cast-iron plates and girders. The leaves of the gates have cast-iron heads, heels, and ribs, in separate pieces with flanges, which are fastened together with nuts and screws; the whole is covered with wooden planking. The docks and gates are stated to have given good satisfaction.

The complete canal-lock was invented by Dionisio and Pietro Domenico in 1481, consisting, as it did, of a lock-chamber inclosed by a double pair of gates. This invention soon spread throughout Europe, and Leonardo da Vinci erected six of them at the junction of the two canals of Milan, 1497. The fall was 17 Milan brasso. (*Milan brasso = 1.725 English feet.*

In 1188, Alberto Pitentino converted the Mincio into a canal and restored it to its ancient course, from whence it had been diverted by the Romans in the time of Quintus Curtius Hostilius. Cresy dates the introduction of locks from the period of the building of this canal. It was a curious contrivance called a conch, with a balance-lever and hanging gate, which somehow opened to allow the boats to pass. This was used at Governolo, to dam up the

Fig. 2981.



Canal-Lock.

waters of the Mincio on the side of Mantua. It was probably a kind of sluice. See Cresy's "Ency. Civil Engineering," pp. 185–188.

The first canal-lock in England was constructed by John Trew of Glamorganshire for the Exeter Canal. The lock-chambers were 300 feet in length, 80 in breadth at top, 50 at the bottom. The gates were in pairs, at each end, 25 feet high, and each leaf 20 feet wide, furnished with iron and brass work that they might be moved with facility. Sluices were made to admit and remove the water in locking. The object was to ascend to a level in the river Ex, above a weir constructed across the river.

This account disproves the statement that locks were introduced into England by Vermuyden, a Dutch engineer, in the time of Charles I.

A substitute for the lock is found in the *canal-lift*, which is used in some cases, but not with boats of large capacity. See LIFT, CANAL.

b. An embankment or structure confining the waters of a canal or race. A *weir* or *guard-lock*.

3. (*Printing.*) To wedge up a form in a chase by means of *sticks* and *quoins*.

4. A cotter or key; as the one which fastens the

cap-square over the trunnion of a mounted cannon. A *forelock.*

5. (*Fire-arms.*) The firing apparatus of a gun, usually consisting of a trigger, sear, hammer, and mainspring. See GUN-LOCK.

6. A fastening for the ends of a hoop which incloses a bale. See BALE-TIE.

7. (*Vehicle.*) *a.* A device to keep a wheel from turning in descending a hill. See WAGON-LOCK; CARRIAGE-LOCK; CAR-BRAKE, etc.

b. The swerving to the right or left of the fore carriage of a vehicle, deviating from the line of direction of the hind wheels and the trend of the carriage proper. It is called the *haw* or the *gee* lock respectively, according as it is to the left or the right of the driver.

8. (*Plastering.*) The projection of the plaster or cement behind the lath, which keeps it from falling or scaling off.

See under the following heads: —

Air-lock.
Alarm-lock for tills.
Bag-lock.
Bolt.
Book-edge lock.
Box-lock.
Broach.
Burglar-alarm lock.
Canal-lock
Cannon-lock.
Car-door lock.
Carriage-lock.
Car-seat lock.
Case-lock.
Cell-door lock.
Check-lock.
Chest-lock.
Clasp-lock.
Dead-lock.
Detector-lock.
Dial-lock.
Dog.
Door-lock.
Double lock.
Drawer-lock.
Fence.
Firelock.
Flint-lock.
Forelock.
Fuse-lock.
Guard-lock.
Gun-lock.
Hasp.
Hasp-lock.
Keeper.
Key.
Key-fastener.
Keyhole protector.
Latch.
Latch-key.
Letter-lock.
Lift-chain.
Lift-chamber.
Lift-latch.
Lift-lock.
Locker.
Lock-file.
Lock-gate.
Locking-forceps.
Lock-nut.
Lock-paddle.
Lock-piece.
Lock-pulley.
Lock-rail.
Lock-saw.
Lock-sill.
Lock-stitch.
Lock-up valve.
Lock-weir.
Matchlock.
Mortise-lock.
Multiple bolt.
Night-latch.
Nut-lock.
Oar-lock.
Padlock.
Percussion-lock.
Permutation-lock.
Piano-lock.
Pick-lock.
Puzzle-lock.
Rabbeted lock.
Reversible lock.
Rim-lock.
Ring lock.
Rose-lock.
Rowlock.
Rural lock.
Safe-lock.
Sash-lock.
Screw-lock.
Seal-lock.
Shutter-lock.
Spindle.
Spring-lock.
Staple-lock.
Stump-lock.
Tentation-lock.
Tide-lock.
Till-lock.
Time-lock.
Trunk-lock.
Tumbler.
Tumbler-lock.
Tusk.
Valise-lock.
Wagon-lock.
Ward-lock.
Wheel-lock.
Window-lock.

Lock-bay. (*Hydraulic Engineering.*) The pond or space of water between the gates of a canal-lock.

Lock-chain. (*Vehicle.*) A chain employed to lock the wheels by attaching a part of the rim to some non-rotating part of the vehicle. Or a chain by which is secured to the vehicle a *skid-plate*, on which the wheel rides in descending a hill. A *skid-chain.*

Lock-cham'ber. (*Hydraulic Engineering.*) That part of a canal-lock, between the gates, in which a boat rises or sinks to the level above or below. See CANAL-LOCK.

Lock-cramp. An implement used to restrain the spring in putting the parts of a gun-lock together.

Lock'er. (*Nautical.*) A compartment in a ship for stowing away things.

The chain-lockers are centered around the foot of the main-mast.

Shot-lockers are recesses and shelves for shot.

Lockers in the cabin are for various articles, answering to closets, and may be fastened by a lock.

Lock'et. 1. (*Arms.*) That part of a leathern sword-scabbard where the lock is fastened.

2. (*Jewelry.*) *a.* The fastening of a necklace, etc.

b. A gold case with a snapping cover, and adapted to contain hair or a miniature.

Lock-file. A slitting file, knife-shaped, for cutting out the wards in the bit of the key. See FILE.

Lock-fil'ers' Cramp. A pair of leaden or brazen cheeks for a vise.

Lock-gate. (*Hydraulic Engineering.*) A pair of closed doors at one end of a canal-lock, to confine the water in the chamber. The gates at the end of the lock-chamber are respectively the *head-gates* and *tail-gates.* See CANAL-LOCK, p. 440.

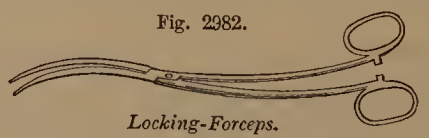
The lock-gate consists of two *leaves*, each having a top and bottom cross-piece, diagonal brace, *quoin-post*, also known as a *heel-post;* and *miter-post*, also known as a *meeting-post.* One pair of gates constitute the *head-gate;* the lower pair form the *tail-gate;* the two, with the *side-walls*, inclose the *lock-chamber.*

Lock-hatch. (*Hydraulic Engineering.*) The sluice-board or sliding-gate in a sluiceway.

Lock-hole. The recess in a musket-stock to receive the lock.

Lock'ing-for'ceps. A light forceps whose arms are automatically locked when closed; used for various purposes, such as holding a sponge tent in uterine operations, for carrying lint, etc.

Fig. 2982.



Locking-Forceps.

Lock'ing-plate. 1. (*Horology.*) Or *count-wheel.* A notched circular plate on the great wheel, whose notches receive the end of a lever attached to the *lifting* piece, and by which the number of strokes is governed.

2. (*Vehicle.*) A plate on a vehicle to take the wear of the fore-wheel when the vehicle is turning short. A *rub-plate.*

Lock-nail. One of the pins by which the parts of a gun-lock are secured to the *lock-plate.* In the old form of lock, they are the *tumbler-pin, main-spring-screw, sear-pin, bridle-screw pin, hammer-nail, hammer-spring screw.*

Lock-nut. A supplementary nut screwed down upon a primary one, to prevent its shaking loose. A *jam-nut, check-nut,* or *pinching-nut.*

A *nut-lock* is a means for preventing a nut from turning. See NUT-LOCK.

Lock-pad'dle. (*Hydraulic Engineering.*) A sluice for filling an empty lock-chamber.

Lock-piece. In guns of the old construction, a lug cast just alongside of the vent for the attachment of the lock.

Lock-plate. That plate on which the parts of a gun-lock are fastened, and which is screwed to the stock.

Lock-pul'ley. (*Machinery.*) Two pulleys formed to rotate together or separately, at will. One of them slips on a *spline*, and has a pin which locks into a hole in the face of the other pulley. See PULLEY.

Lock-rail. (*Carpentry.*) Of a door-frame, the

transverse piece which separates the main doorway from the open space above it, which is usually occupied by a glazed sash. A *transom*.

Lock'ram. (*Fabric.*) (Fr. *Locronan*, a town of Bretagne.) A hempen cloth.

Lock'rand. (*Masonry.*) A course of bond-stones.

Lock-saw. A *compass-saw* used in cutting seats for locks in doors. It has a fine, taper, flexible blade. See COMPASS-SAW.

Lock-screw. The screw which fastens the gun-lock to the stock.

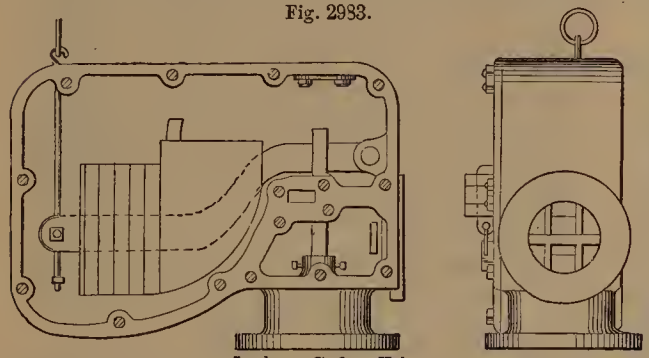
Lock-sill. (*Hydraulic Engineering.*) A piece of timber at the threshold of a canal-lock, with a chamfered edge, against which the gates shut.

Lock-stitch. A sewing-machine stitch in which the lower thread is made to pass over the upper one, simply interlocking therewith. See STITCH.

Lock-tool. A cramp used in putting the parts of a gun-lock together.

Lock-up Safe'ty-valve. A safety-valve which is so inclosed that weight cannot be surreptitiously added to the lever; as in the example, in which the lever and weights are inclosed in a lock-up chamber which the steam does not enter, so that they are secure from access by any not possessed of the key, and can be inspected at any time. A rod passing through the

Fig. 2983.



Lock-up Safety-Valve.

chamber-top enables the engineer to blow off, but affords no facility for holding down the valve.

The lock-up valve was a feature in the specification of a locomotive, for which a prize was offered in 1829, and won by Stephenson's "Rocket."

Lock-wag'on. A device to impede or arrest the motion of one or more wheels of a vehicle when descending a hill, or when it is desired to prevent its being moved. See WAGON-LOCK.

Lock-weir. A weir having a lock-chamber and gates.

Lo'co-mo'tive. A self-moving, traveling steam-engine.

Watt's patents of 1769 and 1784 included the uses of steam-engines for running carriages on land, but he never made any such.

A locomotive was made by Cugnot, a Frenchman, in 1769. It is still preserved in the museum of the Conservatoire des Arts et Métiers at Paris, and is described as having a copper boiler, much like a common kettle, and a pair of 13-inch single-acting cylinders, which operated a single driving-wheel roughened on its periphery. Hornblower's steam-carriage had the same date, 1769.

Symington showed a model of a steam-carriage in Edinburgh in 1770. It was a long-coupled, four-wheeled carriage, the boiler and engine behind, a coach-body on the usual springs, and in front the guard, who governed the fore-wheels by a lever. To the piston-rod was attached a rack gearing into a pinion on the driving-wheel axle. The writer cannot state whether the said pinion was a ratchet, and allowed the rack to *slip* back on its return stroke, or whether it was thrown out of gear in returning while the cylinder on the other side became effective. Its mode of coupling the power to the running-gear resembled, in some respects, his steamboat.

In 1784, William Murdoch of Redruth, Cornwall, England, while in charge of the Boulton and Watt pumping-engine, made a locomotive wherein a lamp supplied the heat. Determining to give it a trial on a road, he lit the lamp beneath the boiler, and as soon as the working parts were thrown into gear, the thing started and got away from him, he following it along the lane at full speed. The night was dark, and the locomotive met and scared the clergyman of the parish, who raised a cry of distress, thinking he had met the Evil One. This locomotive was exhibited before the Institution of Mechanical Engineers in 1850, 66 years after its construction.

Oliver Evans of Philadelphia obtained a patent in Maryland in 1787 for the exclusive right to make steam-wagons for roads and railways. The details of the invention are not known to the writer. His descendants in the third generation are yet inventing. He is entitled to the credit of first making the double-acting high-pressure steam-engine a success. In 1801, he built a floating dredging-machine, to which he fitted wheels connected with the engine, and conveyed it 1½ miles to the place of launching. See HIGH-PRESSURE STEAM-ENGINE.

It is stated, that about 1803, a Mr. Frederieks made a locomotive for a silver-mine in Hanover. The principles of construction are unknown.

In 1806, a locomotive to be driven by hot air was constructed by Niepce at Chalons, France.

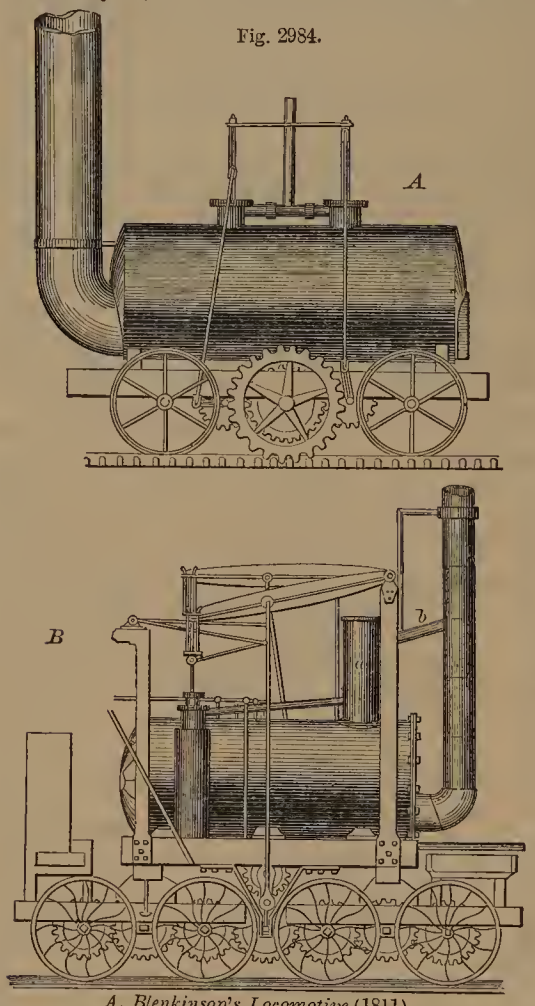
Trevethiek's locomotive had a single cylinder, laid horizontally below the bottom or front part of the boiler, its reciprocating piston-rod being connected by another rod with a crank, at the midlength of an axle which carried a fly-wheel and a pair of cog-wheels, which geared into other spur-wheels on the axle of the driving-wheels. The engine was run upon a railway at Merthyr-Tydvil, in 1802, and drew ten tons in addition to its own load at the rate of five miles per hour. Vivian was associated with Trevethick in the patent. It was high-pressure, non-condensing, and exhausted into the chimney. It may be considered the first locomotive to run on rails or trams.

Blenkinsop's locomotive, in 1811, gave still better satisfaction to its owners, and it was usefully employed at the Middleton Colliery in hauling coals on a tramway, the engine having spur-wheels working into a rack on one side of the track. The engine (*A*, Fig. 2984) was otherwise supported on four wheels. The fire was built in a large tube passing through the boiler, and the tube was bent up at the end to form a chimney. Two vertical cylinders were placed above the boiler, and the pistons were connected by cross-heads and connecting-rods to cranks on the axles of spur-pinions, which geared into the main spur-wheel, which formed the driver. It was long used on a colliery railway between Leeds and Middletown, 3½ miles distant, and perhaps was the first successful locomotive in regular use. It drew trains of 30 tons weight 3¾ miles per hour.

In 1812, Blackett made a series of experiments which proved that the expedient of a pinion and rack-rail was unnecessary; and Chapman patented a

locomotive with eight wheels driven by gearing, for the purpose of increasing the tractive adhesion. In the same year, Brunton invented a means of driving

Fig. 2984.



A, *Blenkinsop's Locomotive* (1811).
B, *Hedley's Locomotive* (1813).

a locomotive by two propellers consisting of jointed rods intended to imitate the action of the hind legs of a horse. Analogous contrivances were adopted by Gordon and Gurney.

In the spring of 1813, William Hedley built a locomotive with four smooth drive-wheels, to run on a smooth rail. The machine failed to accomplish much, on account of its small boiler. Hedley thereupon the same year built another engine (shown at *B*, Fig. 2984), having a return-flue boiler, and mounted on eight driving-wheels, which were coupled together by intermediate gear-wheels on the axles, and all propelled by a gear in the center, driven by a pitman from the walking-beam. See "Who Invented the Locomotive-Engine?" London, 1858, written by O. D. Hedley, the son of the inventor.

Hedley's locomotive was objected to by residents of Newcastle, on account of the smoke. He therefore passed the smoke into a large receiver (*a*), and turned the exhaust-steam upon it. From the receiver the steam and smoke were conveyed by a pipe (*b*) to the chimney, which device soon developed into the steam-blast.

"Puffing Billy" was at work more or less until 1862, when it was laid up as a memorial in the British Patent Office Museum. Hedley died in 1842.

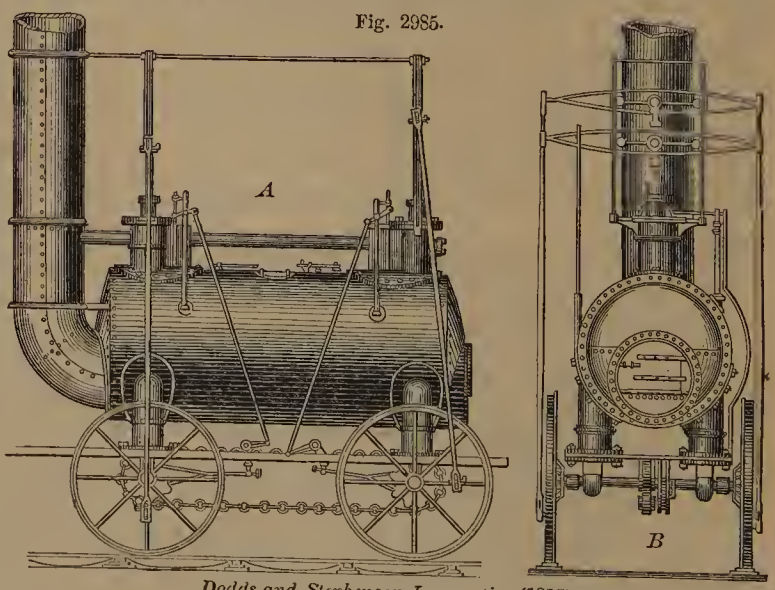
In 1815, Dodds and Stephenson patented an engine (shown by side and end views, Fig. 2985), in which the power might be applied either through wrists, at angles of 90° to each other on the driving-wheel, or an endless chain working in gearing on the axles. A patent was taken out in the succeeding year by Losh and Stephenson, embracing, among other features, a series of cylinders communicating with the water in the boiler, and having pistons with rods at their lower ends, which were caused to press upon axles having vertically movable bearings, so as to keep the wheels down when running on an uneven track. Their first engine is stated to have been made for the Killingworth Railway, and their engines were employed on iron tracks by the Stockton and Darlington Railway in 1825, and, later, at the Newcastle collieries. The locomotive in the Stockton and Darlington Railway had two vertical cylinders, and the driving-shaft had cranks at an angle of 90°. The axles of the wheels were coupled by an endless chain passing around both axles.

In 1829, the Liverpool and Manchester Railway, then the most extensive and finished work of the kind ever undertaken, was completed, and the directors offered a reward of £500 for the best locomotive, which should fulfill certain imposed conditions. Among these were, that it was to consume its own smoke, draw three times its own weight at a rate of not less than 10 miles an hour, and the boiler-pressure was not to exceed 50 pounds per square inch. The weight was not to exceed six tons, nor the cost £550.

Three engines competed for the prize: the "Rocket," constructed by George Stephenson; the "Sanspareil, by Timothy Hackworth; the "Novelty," by Messrs. Braithewaite and Ericsson.

The "Rocket" weighed 4 tons 5 cwt., and its tender, with water and coke, 3 tons 4 cwt. It had two loaded carriages attached, weighing a little over 9 tons 10 cwt. The greatest velocity attained was 24½ miles per hour, and the average consumption of coke per hour 217 pounds. See *A*, Fig. 2986.

Fig. 2985.



Dodds and Stephenson Locomotive (1815).

The "Sauspariel" attained a speed of 22¾ miles per hour, but with an expenditure of fuel per hour of 692 pounds.

The "Novelty" carried its own water and fuel. In consequence of successive accidents to the working arrangements, this engine was withdrawn from competition. A fourth engine, the "Perseverance," by Burstall, not being adapted to the track, was withdrawn.

The opening of the Liverpool and Manchester Railroad, September 15, 1829, was an era in civilization, and perhaps the first victim to the iron horse was slain on that day, — Mr. Huskisson, Home Secretary in the British Cabinet. Eight locomotives were used on that day, and while the engines were watering at the Parkside station some of the guests descended to the road. While Mr. Huskisson was talking to the Duke of Wellington, the famous "Rocket" came by, knocked down Mr. Huskisson, and the wheels passed over his left leg. He was placed on board the "Northumbrian," driven by George Stephenson, who conveyed him 15 miles in 25 minutes, at the rate of 36 miles an hour, the most marvelous achievement yet. Mr. Huskisson died the same night at Eccles.

The "Rocket" engine was superseded in 1837, being condemned for life to the collieries. Here it proved itself capable of a rate of 60 miles an hour; but being again convicted of levity while on duty, it was cashiered and its place filled by heavier machines of 12 tons. After a few years of inglorious retirement, some one, not totally oblivious of how it would look in history, recalled the old soldier from his limbo, and now he enjoys the company of his elder brother, Hedley's "Puffing Billy," in the English Patent Museum.

In Fig. 2986, *A* is an elevation of the "Rocket." The boiler *a* is a cylinder 6 feet long, and has 25 tubes. This feature was due to Mr. Henry Booth, though a tubular boiler had been patented by M. Seguin in France, in 1828. The fire-box *b* has two tubes, communicating with the boiler below and above, and is surrounded by an exterior casing, into which the water from the boiler flows and is maintained at the same level as that in the boiler.

B is a longitudinal vertical section of a modern English locomotive. The boiler is surrounded by two casings, one within the other, united by stays. The tubes *a* are of brass, 124 in number, and the boiler has longitudinal stays connecting the ends. *b* is the smoke-box, into which the blast-pipe *c* discharges. *d* is the steam-dome, into which the steam from the upper part of the boiler enters, its amount being governed by a regulator controlled by a winch. This serves to obviate in great degree the effects of priming. The steam-pipe *e* has two branches, each entering one of the boxes containing the valves by which the flow of steam to the cylinders is controlled.

C is an express-engine designed by Gooch for the Great Western Railway, where an unusual rate of speed is maintained. The boiler has 305 tubes, 2 inches in diameter. The cylinders are 18 inches diameter and 24 inches stroke, the driving-wheels 8 feet in diameter, the heating surface of the fire-box 153 square feet.

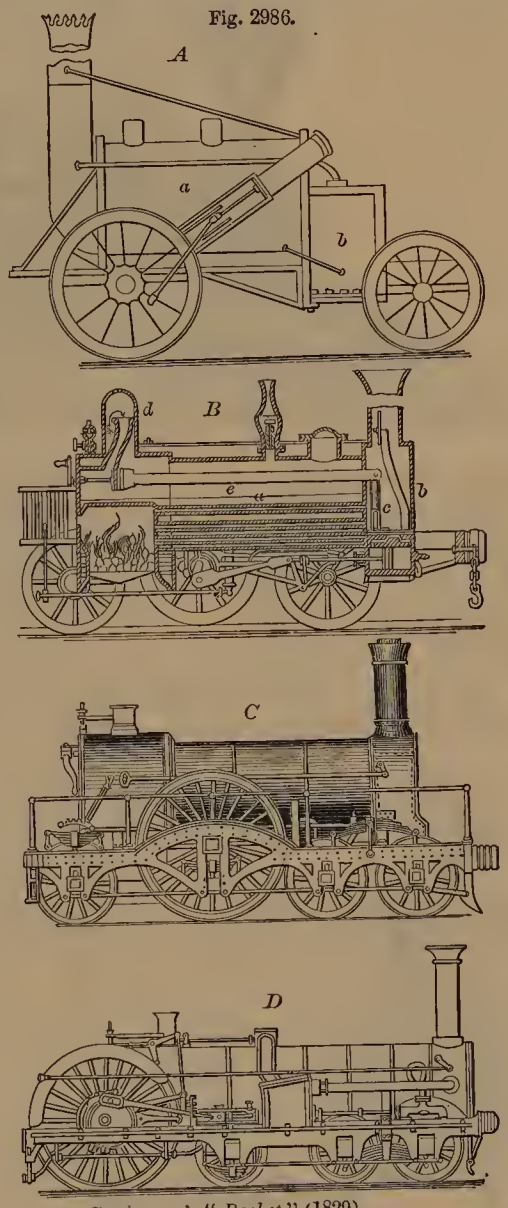
D is an express-engine designed by Crampton for the same road. It is adapted for the usual gage.

For details of English locomotives, which differ considerably in construction from those used in the United States, the reader is referred to Colburn's "Locomotive Engineering."

The engines employed on the Irish mail-trains between London and Holyhead weigh 27 tons; the tenders 17 tons, carrying 2 tons of coke and 1,500 gallons of water. The cylinders are of 16 inches diameter and 24-inch stroke. The apparatus for feeding the fuel also provides for the combustion of the smoke. The engine is supplied with water while running, from a trough beneath the rails, from which the water is scooped up by the tank. The cost of a locomotive of this description is nearly £3,000. It is said that one of them has been known to run 130 miles in 144 minutes.

Faulding's locomotive (English) is designed to avoid the inertia of its working parts. It has an

Fig. 2986.



A, *Stephenson's "Rocket"* (1829).
B, *English Locomotive* (*Longitudinal Section*).
C, *Gooch's Express Engine* (*English*).
D, *Crampton's Express Engine* (*English*).

oscillating cylinder on each side, which is, by a partition at its midlength, divided into two cylinders, each of whose pistons, coupled directly to the crank-pins, propels one of the four driving-wheels, and is simultaneously driven outward and inward. The crank-axles are at right angles with each other, so that each wheel is driven alternately. The cylinders are carried on a frame supported by the journals of the driving-wheels, so as not to be affected by the motion of the springs.

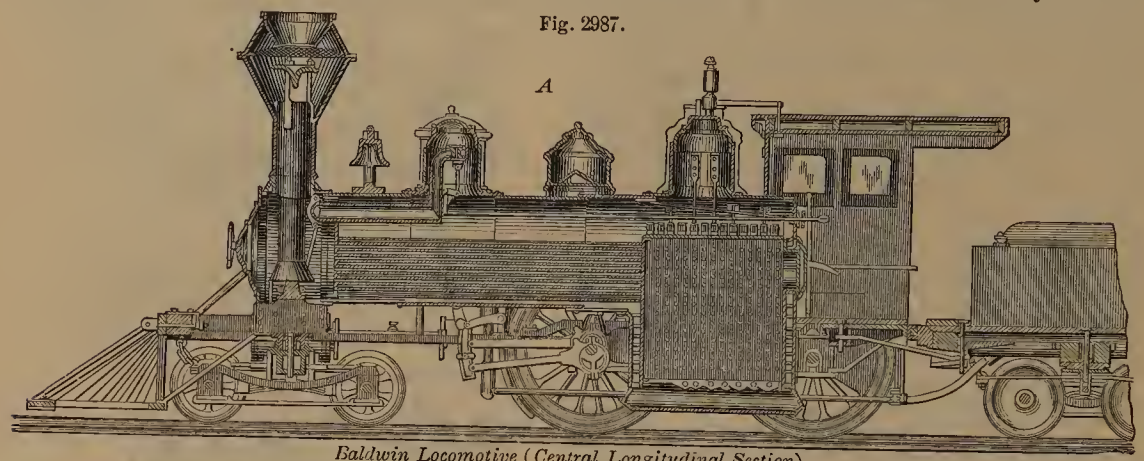
The first locomotive run on rails outside of England was the "Stourbridge Lion," made by Stephen-

son and brought from England for the Delaware and Hudson Canal and Railroad Company by Horatio Allen. This was in August, 1829. It was soon found that English locomotives, adapted for gentle curves, were ill suited for the exigencies of American railroads, where curves of as small a radius as 200 feet were sometimes employed. Mr. Peter Cooper, since so well and widely known, devised an engine which solved the difficulty. This was in 1829.

The second locomotive built in the United States for actual service was for the South Carolina Railroad, and made its first regular trip in March, 1831. See RAILWAY.

The London "Engineer" describes an engine built for the Mt. Cenis Railway as having four drivers and four horizontal wheels, which latter grasp between them a central rail with an amount of pressure regulated by springs, which are controlled by bars bearing upon them, and adjusted by means of a shaft extending across the engine and furnished with right and left handed screws. This shaft carries on its end a worm-wheel, gearing into a worm connected with a hand-wheel on the foot-plate, by which the pressure is regulated. This may be increased to 24 tons, 6 on each wheel.

Fig. 2987.

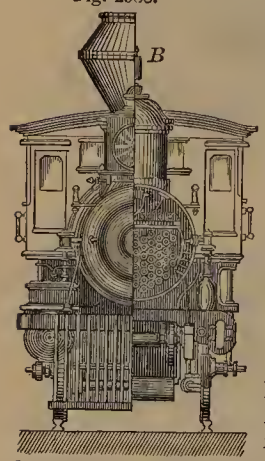


Baldwin Locomotive (Central Longitudinal Section).

Fig. 2987 is a central longitudinal section of an approved form of American locomotive as made at the Baldwin Locomotive Works, Philadelphia.

Fig. 2988 is a front elevation, one half of which shows a transverse section through the boiler. The engine has four drivers, 60¾ inches in diameter, and a four-wheeled swing bolster truck, and weighs, with water and fuel, about 65,000 pounds. The flues, 144 in number, are 2 inches in diameter, and 11 feet 5 inches in length. The fire-box, of cast-steel, is 66 inches long, 34½ inches wide, and 63 inches deep. Water-space 3 inches sides and back, 4 inches front. Grates, cast-iron. The cylinders are horizontal. Valve-motion graduated to cut off at any point of the stroke. The tires of cast-steel, and the wheel-centers of cast-iron with hollow spokes and rims; the wrist-pins of cast-steel, the connecting-rods of hammered iron. The truck-wheels are 28 inches in diameter. All the principal parts of the engine are interchangeable.

Fig. 2988.



Baldwin Locomotive (End Elevation and Transverse Section).

Attempts are being made, by adaptation of the furnace and boiler, to run locomotives by means of liquid fuel. Differences also occur in the construction of the heating parts, according to the character of the fuel, — coal, coke, wood, peat, etc.

The ordinary speed attained on English railways is greater than that usual in this country. The Great Western express from London to Exeter travels at the rate of 43 miles an hour including stoppages, or 51 miles an hour while actually running. Midway between some of the stations a speed of 60 miles is attained, and on experimental trips 70 miles an hour has been reached. A speed of 75 miles is equivalent to 35 yards per second, so that if a row of stakes one yard apart were driven at the side of the road, they would at this velocity appear undistinguishable one from another. Were the driving-wheels of the locomotive 7 feet in diameter, they would revolve 5 times in a second, each piston would traverse the cylinder 10 times per second, while there would be 20 discharges of waste-steam per second, causing a continuous sound instead of the "cough" which is heard when the engine is moving slowly.

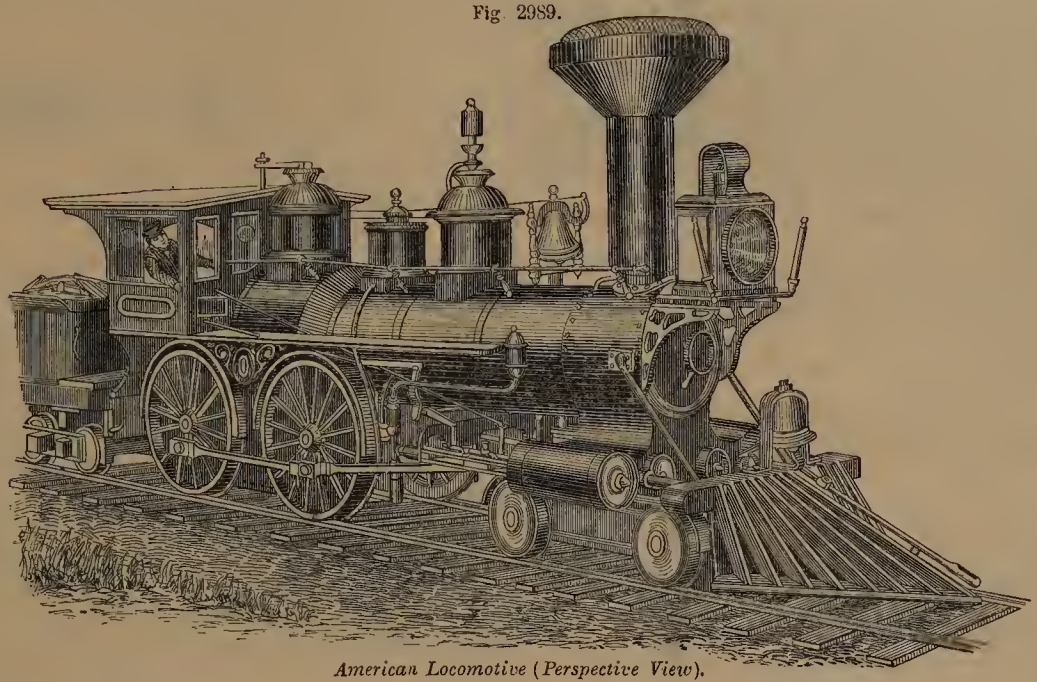
Very high speeds have been attained, on special occasions, on American roads, probably fully equaling any time ever made in England. For instance, it is stated that a train conveying some officials of the New York Central Railroad made the distance from Rochester to Syracuse, 81 miles, in 61 minutes, said to be the fastest time ever made in America.

The life of a locomotive-engine is stated in a paper read before the British Association at thirty years. Some of the small parts require renewal every six months. The boiler-tubes last five years, and the crank-axles six years; tires, boilers, and fire-boxes, seven to ten years. The side-frames, axles, and other parts, 30 years. During this period, the total cost of repairs is estimated at $24,450 in American money, the original cost of the engine being $8,490. It therefore requires for repairs in eleven years a sum equal to its original cost. In this time it is estimated that an engine in average use has run 220,000 miles.

See Clark's "Recent Practice on the Locomotive"; Tredgold on "Locomotive-Engines," London, 1851; Heusinger and Clauss's "Locomotive Maschine," Wiesbaden, 1858; Weissenborn's "American Engineering," New York, 1861; "The Student's Guide to the Locomotive," London, 1849.

The following figures, from the *Railway Times*, show the result of locomotive performance on the Cleveland, Columbus, Cincinnati, and Indianapolis Railway, 397 miles, for the month of March, 1872, and may be interesting in this connection: —

Fig. 2989.



American Locomotive (Perspective View).

Miles run by passenger trains	53,222
Miles run by freight trains	201,346
Miles run by other trains	67,446
Total mileage	322,014
No. of miles run to 1 pint of oil	23.23
No. of miles run to 1 ton of coal	40.52
(Miles run with coal, 158,018.)	
Cost per mile run for repairs	4.15 cents.
Cost per mile run for stores	.55 "
Cost per mile run for fuel	7.40 "
Cost per mile run for E., F., and W.	7.10 "
Total cost per mile run	19.20 cents.
Total pints of engine-oil used	8,027
Total pounds of tallow used	3,693½
Total pounds of waste used	1,951
Total quarts of oil used	1,928½
Total tons of coal used	2,461

The prineipal parts of a locomotive are, —

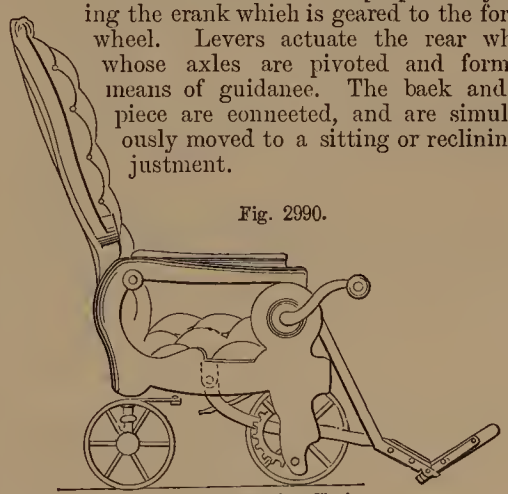
Air-brake.
Air-brake eylinder.
Air-pipe.
Air-pump.
Air-valve.
Ash-box.
Axle-boxes.
Bell.
Bell-cord.
Bell-crank.
Bell-standards.
Blow-off eock.
Boiler.
Braces.
Cab.
Center-easting.
Cheek-valve.
Chimney.
Clock.
Cone.
Convey-pipe.
Coupling-bar.
Coupling-pin.
Counterbalanee.
Cross-head.
Crown-bars.
Crown-sheet.
Cylinder.
Cylinder-cocks.
Diseharge-valve.
Dome.
Drivers.
Dry-pipe.
Eccentrics.
Eeeentrie-rods.
Eccentrie-straps.
Equalizing-bar.
Feed-pipe.
Fire-bars.
Fire-box.
Fire-door.
Fire-grate.
Flag.
Flag-staff.
Flues.
Flue-plates.
Foot-board.
Frame.
Gage-cocks.
Galoot-spring.
Grate-bars.
Guides.
Hand-rail.
Hangers.
Head-light.
Head-plate.
Injector.
Lamp.
Link-motion.
Low-water alarm.
Main-rod.
Man-hole
Man-hole plate.
Oil-cups.
Parallel-rods.
Pet-eock.
Pilot.
Pipes.
Piston.
Piston-rod.
Reeeiving-valve
Reflector.
Reverse-bar.
Rocker-arm.
Running-board.
Safety-chain.
Safety-valve.
Sand-box.
Saud-pipe.
Slide-valve.
Smoke-box.
Smoke-stack.
Spark-arrester.
Springs.
Steam-dome.
Steam-gage.
Swing-bolster.
Tallow-cups.
Throttle-bar.
Throttle-lever.
Throttle-valve.
Truek.
Valve-gear.
Water-eocks.
Water gage.
Wheels.
Whistle.
Whistle-cord.
Whistle-valve.
Wrist.

Lo'co-mo'tive-boil'er. (*Steam-engine.*) A boiler with numerous flues eonneeting the fire-box with the smoke-box beneath the chimney. See LOCOMOTIVE.

Lo'co-mo'tive-car. (*Railway.*) A locomotive and car eombined in one vehiele.

Lo'co-mo'tive-chair. A wheeled ehair for an invalid. That shown is propelled by turning the erank whieh is geared to the forward wheel. Levers actuate the rear wheels, whose axles are pivoted and form the means of guidanee. The baek and foot piece are eonneeted, and are simultaneously moved to a sitting or reclining adjustment.

Fig. 2990.



Locomotive-Chair.

Lo'co-mo'tive-fur'nace. (*Steam-engine.*) The fire-box of a locomotive. See LOCOMOTIVE.

Lo'co-mo'tive Pile-en'gine. A pile-driver.

Lo'co-mo'tive-pump. (*Steam-engine.*) The

feed-pump by which a locomotive-boiler is supplied with water. See INJECTOR.

Lo'co-mo'tive Smoke-pipe. The chimney-stack of a locomotive. See LOCOMOTIVE.

Lo'co-mo'tive Valve-gear. (*Steam-engine.*) The means by which the engineer governs the motions of the valves, opening, closing, or reversing. See LINK-MOTION.

Lode. 1. (*Mining.*) A regular vein affording metal.

When parallel to the axis of elevation of the district, it is termed *right running.*

When at right angles to the said axis, it is termed a *cross course.*

When at an angle of 45°, it is termed a *contra-lode* or *counter.*

A *rake-vein* is a perpendicular mineral lode.

A *live vein* or lode is one which contains metallic ores. It is said to be a *dead* lode when the ores give out.

The *back* is the upper part of a *lode.*

The *walls* or *checks* are the sides of the *lode;* as the vein inclines, the *walls* are known as the *upper* or *hanging* wall and the *under* wall.

The *hade* or *hading* is the slope or inclination.

The *bearing* is the course or direction.

The *country* is the rock traversed by the *lode* or *vein.*

Side-lodes, strings, feeders, and *branches* are minor ramifications of a vein or lode.

The *gangue* is the non-metalliferous portion of the vein. (German, *Gang,* vein.)

A *heave* or *fault* is a displacement or dislocation of a vein.

Gossans are surface indications of a vein.

Bunches, nests, concretions, nodules, are detached masses of different characters.

2. (*Hydraulic Engineering.*) A reach of water in a canal, or slack-water navigation.

Lodg'ing-knees. (*Shipbuilding.*) Compass-timbers lying horizontally and securing the junction of the deck-beams with the frames.

Lodg'ment. (*Fortification.*) An intrenchment hastily thrown up in a captured work to maintain the position against recapture.

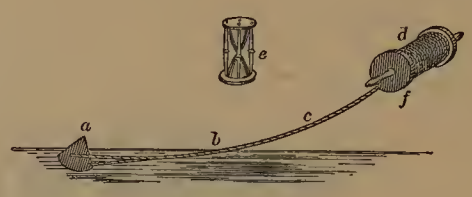
Loft. (*Architecture.*) *a.* An elevated gallery in a church, for an organ or choir.

b. An elevated story in a barn or stable, as a *hay-loft* above the floor on which the animals are stalled.

Log. 1. (*Nautical.*) A device for ascertaining the rate of a ship's motion. In its common form it consists of a triangular piece of wood, called the *log-chip,* curved at the bottom, which is loaded so that it may float upright in the water. It has a radius of about 6 inches, and a thickness of ¼ inch. To its corners is attached a cord, termed the *log-line,* which is wound around a reel, the axis of which projects, allowing it to turn freely when held in the hollow between the thumb and forefinger. The line is long enough to measure the distance sailed by the ship at her greatest speed during a given time, usually 30 seconds, and is divided into *knots,* corresponding to a proportionate part of the nautical mile, that is, 51 feet, though some navigators make it a trifle longer or shorter, as they conceive that the ship overruns or underruns her reckoning.

The string is knotted at such intervals that the spaces bear the same relation to a nautical mile that a half-minute does to an hour. That is, the knots must be the 120th of a nautical mile apart. The English geographical or nautical mile is $\frac{1}{60}$ of a degree of latitude, about 2,025 yards. Each *knot* is therefore $50\frac{7.5}{120}$ feet. For ordinary land measure, the English statute mile is used, = 5,280 feet. A knot would be 44 feet. See PEDOMETER.

Fig. 2991.



Log.

a, log-chip.
b, stray-line.
c, forerunner or *stray-mark.*
d, log-line.
e, sand-glass.
f, reel.

A certain length of line — not marked — intervenes between the chip and the first division on the line. This is termed the *stray-line,* and serves to allow the chip to drift beyond the dead-water in the wake of the ship.

Each knot is made sensible to the feeling as well as to the sight, and is subdivided into ten fathoms, so called. The time is measured by a small sand-glass. In heaving the log, the observer, usually an officer or petty officer, throws the chip over the taffrail, and as the first mark on the line passes over the reel, calls out "turn" to the assistant, who immediately inverts the glass. When the sand has all run out the latter calls out "out," when the observer checks the line, noting the knots and fathoms which have passed out. This operation, in well-regulated vessels, is performed every hour, and the result, as well as the course by compass which the vessel is steering at the time, is entered in the log-book, to serve as a basis for the *dead reckoning.* Sometimes, as in the British navy, a 28″ glass is employed, the length of the line being proportionately reduced.

Estimating a mile at 6,139.75 feet, and using a 30″ glass, —

1 knot = 51.1629 feet, or 51 feet 1.95 inches.
1 fathom = 5.11629 feet, or 5 feet 1.395 inches.

If a 28″ glass is used, and 8 divisions, then —

1 knot = 47 feet 9.024 inches.
1 fathom = 5 feet 11.627 inches.

The line should be about 150 fathoms long, having 10 fathoms between the chip and first knot for stray-line.

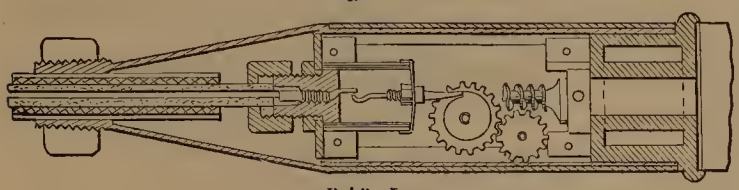
Bowditch gives 6,120 feet in a sea-mile, which, if taken as the length, with a 28″ glass, will make the divisions 47.6 feet and 5.95 feet.

Some logs, the earliest of which, perhaps, was Massey's, are actuated by wings on a rotating rod, which turns as the vessel passes through the water, operating, by means of an endless screw, a series of multiplying wheels, which register the total distance run between the time the log was thrown overboard and that at which it was taken from the water. These are only taken in when the ship's course is changed, or when the speed is below two or three knots per hour. They are somewhat liable to turn up missing, owing probably to their being bitten off by sharks.

Reid's log is of this class, but the spindle which carries the wings is combined with a mechanism for breaking galvanic circuit upon a certain number of rotations of the spindle. The armature operates a registering mechanism.

The "Berthon log" is an adaptation of Pitot's tube. In its elementary form it consists of a small tube passing through the ship's keel nearly amidships, and carried up to any convenient hight, when

Fig. 2992.



Reid's Log.

it is curved downward and united to the leg of an inverted siphon containing mercury. When the ship is making headway, the water which enters the tube through an aperture near its lower end rises, forcing up the mercury, which indicates the ship's speed on a suitable register. By turning the tube so that the aperture forms a certain angle with the keel, the ship's draft may be ascertained.

In reference to this subject Humboldt says, —

"It has frequently been asserted that the use of the log for measuring a ship's way dates back only to the end of the sixteenth or beginning of the seventeenth century, the year 1607 being usually assigned as the period when the first mention of it occurs. Navarrete says that it was used on board English ships in 1577, and that in Magellan's time the ship's speed was estimated by the eye. On the contrary, Pigafetta, a companion of Magellan, speaks of the log, *la catena a poppa*, as of a long-known means of measuring distances at sea.

"The Romans, in the time of the Republic, had in their ships an apparatus for measuring the distance passed over, consisting of wheels four feet high, provided with paddles placed outside the ship, after the manner of a modern steamboat, and according to the detailed description of Vitruvius, having a train of gearing consisting of three-toothed wheels, and registering the number of revolutions made by the exterior paddles, and also miles traversed by the ship, by the dropping of small round stones from an aperture in a wheel-case.

"This was constructed on the principle of the odometer (or *hodometer*), which was also employed by the Romans on land, mention being made of a traveling carriage belonging to the Emperor Commodus provided with such an apparatus. Hero of Alexandria, in his manuscript on the *dioptra*, describes an odometer of much more perfect construction, adapted for use both by land and water.

"The earlier nautical works of the Spaniards refer only to the method of arriving at the distance made by estimation; judging the velocity of the ship during the time occupied by the running out of each hour or half-hour glass. This would seem to have involved, on the part of the navigator, if even a rude approximation to accuracy were attained, not only a general knowledge of the usual rate of speed of vessels and an acquaintance with the effects produced by drift and set of the sea, but also with the sailing qualities of the particular vessel in which he happened to be. Medina lays down, as a general rule, that 'the most a ship advances in an hour is four miles, and with feebler breezes three, or even two.' Columbus, in his journal, frequently refers to his disputes with his lieutenant, Pinson, in respect to the distance made by the fleet since leaving Palos, and speaks of making 8 miles per hour, double the speed referred to by Medina. He makes no mention of the log. When it was proposed, in 1495, to determine the Papal line of demarcation between the discoveries of the Spaniards and Portuguese, the distance sailed over was to be determined by the judgment of 20 very experienced mariners, who were to prick off on the chart the distance made by the ship every six hours, according to their estimation. In Pigafetta's journal of Magellan's voyage, he speaks of a 'chain at the poop,' used throughout the entire voyage to measure the way. This would seem to have been an arrangement similar to the log-line, though no mention is made of the sand-glass, the log-chip, or of marks or divisions of the chain."

In connection with this subject, it may be mentioned that Professor Scoresby made careful observations during a passage across the Atlantic and during the prevalence of a protracted storm. He found: —

Extreme altitude of waves above the intervening depressions or hollows .	43 feet.
Mean distance between waves . .	559 "
Extreme distance from crest to crest .	600 "
Interval of time between waves .	16 seconds.
Velocity per hour	32½ miles.

Newton found that the velocity of the waves is as the square roots of their breadths; as taken between the tops of the ridges. Also, that they move through a space equal to their breadth in the same time in which a pendulum oscillates whose length is equal to the distance between the ridges. Waves whose breadth is 39½ inches will move that distance in a second of time. Their motion is progressive, but does not impart a like motion to a floating object, as the water does not move at the rate of the undulations.

2. (*Steam-engine.*) A tabulated summary of the performance of the engines and boilers, and of the consumption of coals, tallow, oil, and other engineers' stores on board a steam-vessel.

3. A stick of timber butted at the ends and ready for sawing.

Log-board. (*Nautical.*) The hinged pair of boards on which the memoranda of time, wind, course, rate, etc., are noted for transcription into the *log-book*.

Log-book. (*Nautical.*) The book which contains a journal of the vessel's progress from day to day, with any event occurring on board, of spoken vessels, etc. It is transcribed from the *log-board*, and forms the *rough-log* from which (in government vessels) the *smooth-log* is transcribed for the navy department.

Log-chip. (*Nautical.*) The triangular board on the end of the *log-line*. See Log.

Log'ger-head. (*Nautical.*) A runnel on the gunwale of a whaleboat, over which the line passes as it is drawn out by the fish.

Log'ging-axe. An axe used in cutting off logs. It is usually heavier than a *felling* or *lopping* axe. A substitute in the *cross-cut* saw, or the *drag* saw.

Log'ging-head. The working-beam of a steam-engine.

Log-glass. (*Nautical.*) The sand-glass used at heaving the log. Half-minute or quarter-minute glasses are used, according to the rate of sailing. See Log.

Log-line. (*Nautical.*) A line 150 fathoms in length. See Log.

Log-meas'ur-er. A device for gaging logs, taking the round measure with the allowance for the squaring, and giving the results in board measure of the ascertained square in running feet of the log.

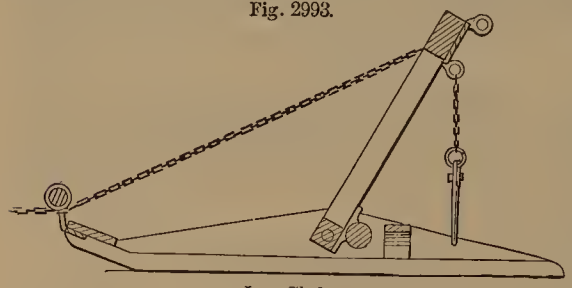
Log'o-type. A type having for its face a whole word or a combination of letters in common use; as, *con*, *com*, *tion*, *ing*, *the*, *and*, *in*, *on*, etc. These com-

pounded types are not now used, but the practice still remains in combinations of letters, such as *ff*, *ffi*.

Log-reel. The reel of the log-line. See Log.

Log-sled. A short, strong, low-benched sled for hauling logs. In the example, the sled has an angular frame provided with trunnions at each end of

Fig. 2993.

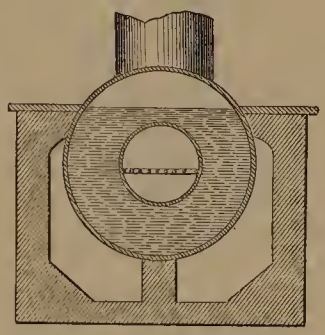


Log-Sled.

its base or lower portion, with bearings in the sides of the sled, and is so connected with a chain and log-hooks that the draft force of the team will act to raise the log and draw it forward upon the sled.

Log'wood. A dyewood obtained from trees of the genus *Hæmatoxylon campeachianum*.

Fig. 2994.



"Small Cornish" Boiler.

Lon'don-boil'er. Also known as the "Small Cornish Boiler." It has a cylindrical fire-tube flue running through it, which contains the furnace and fire-bars. The fire-grate is so arranged with a removable brick bridge, that the whole or any less area of grate can be used that is found most economical.

The current of flame and hot air in this boiler first passes from the fire through the flue-tube to the back end of the boiler, whence it returns under one side of the shell to the front, where it crosses into the other side-flue, through which it proceeds to the chimney in a continuous or *wheel* draft.

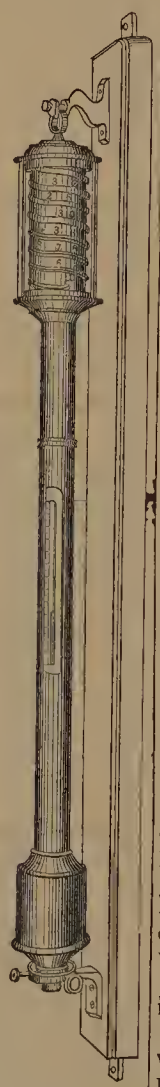
Long-boat. A large ship's boat, from 32 to 40 feet long, having a beam from .29 to .25 of its length. Has a heavy, flat floor, and is sharper in its floor than a *launch*. It is *carvel* built.

Long-bow. (*Weapon.*) A bow the hight of the archer, formerly used in England. See Bow.

Long-cloth. (*Fabric.*) A peculiar kind of fine cotton cloth, made milled or plain.

Long-flax. Flax to be spun its natural length without cutting.

Fig. 2995.



Long-Range Barometer.

Long-plane. (*Joinery.*) A joiner's plane used when a piece of stuff is to be planed up very straight. It is 2 feet 3 inches long.

Long-poil. (*Fabric.*) A shaggy velvet.

Long Prim'er. (*Printing.*) A size of type between *Small Pica* and *Bourgeois*.

Small Pica, 83 ems to a foot.
Long Primer, 89 ems to a foot.
Bourgeois, 102 ems to a foot.

Long-range Ba-rom'e-ter. A barometer, the upper portion of whose tube is in spiral form, and of diminished diameter, the distance between the coils being usually 12 base to 1 perpendicular, so that each inch rise of mercury in the tube is indicated by an advance of 12 inches in the spiral coil, admitting of small variations being read without the aid of a vernier.

In another form, the diameter of the tube is diminished at its upper end, and this, with the upper part of the enlarged portion, is filled with a fluid proportionately lighter than mercury. The indications of the latter are thus multiplied in proportion to the difference between the sectional areas of the contracted and enlarged portions of the tube.

Long-ruff'er. A coarse heckle. See Heckle.

Long-saw. A pit-saw; used by a man standing above the log, and one below.

Long-slide. A slide-valve of such length as to govern the ports at both ends of the cylinder, and having a hollow back which forms an eduction passage. It was invented by Murdoch, of the firm of Boulton and Watt. See Cornish Engine.

Long-tack'le Block. (*Nautical.*) A block having two single sheaves, one above the other. The lower one is ⅔ the size of the upper. It is used in combination with a single block, to form long-tackle for loading or other purchase.

Long-tim'ber. (*Shipbuilding.*) A timber rising from the *cants* and continued in one piece to the top of the second futtock.

Long-tom. 1. A kind of gold-washing cradle.

2. (*Nautical.*) A pivot-gun amidship. See Pivot-gun.

Long-valve. A slide-valve found in some of the Watt engines, and which was long enough to cover the ports at both ends of the cylinder. A *long-slide*.

Long-wool. *Combing* wool; in distinction to the shorter, which is carded.

Loobs. (*Mining.*) The slimes of tin ore.

Loo'er. From *Lour* (Fr. *velour*, velvet), a hatter's brushing-pad. See Lure.

Loof. (*Shipbuilding.*) That part of the bow where the timbers begin to *cant* or curve in towards the *stem*.

Look'ing-glass. The old mirror of Narcissus is older than bronze or glass, and the handful of black liquid still holds its place as the mirror of incantations. (See Mirror.) "As in water face answereth to face" (Prov. xxvii. 19) was a comparison adapted to the comprehension of a people who had left Egypt and the arts behind them for a period of near 500 years.

Mirrors to show the full length of the person were known in Greece and Rome. (*Specula totis paria corporibus.* — Seneca.) Pliny refers to glass mirrors with a backing of leaf-metal, made at Sidon.

Looking-glasses were made in Venice, 1298, and in England at Lambeth, 1693.

"Bought a looking-glass by the Old Exchange, which costs me £5 5*s.*, — a very fair glass." — Pepys's *Diary*, 1664.

Looking-glasses are silvered, as it is called, by the following process: A sheet of tin-foil is placed very

smoothly on a table or stone, and the foil is then flooded with mercury. The glass is laid upon it in such a way as to expel air-bubbles, and heavy weights are laid on the glass. The weights press out the superfluous mercury, and what remains forms an amalgam with the tin, which adheres to the back of the glass. See SILVERING.

Liebig recommended the following solution for silvering mirrors : —

One part nitrate of silver dissolved in 20 parts pure water. Form a solution of nitrate of ammonia, of a specific gravity of 1.115, and a lye of carbonate of soda, specific gravity 1.035, reduced one third by evaporation. The silvering liquid consists of the ammoniated solution, 100 parts ; silver solution, 140 parts ; lye, 750 parts. The application of a separate solution causes a deposition of silver on the glass. See also SILVERING-GLASS.

Siemens has modified the operation, as suggested by Liebig, and greatly simplified the reduction of the silver. Dry ammonia gas is passed through aldehyde to produce aldehyde ammonia ; 2.5 grammes of aldehyde ammonia and 4 grammes nitrate of silver to 1 liter of water is the proper proportion to take. The nitrate of silver and aldehyde ammonia are separately dissolved in distilled water, mixed, and filtered.

The object to be silvered must be thoroughly cleansed to free it of grease, and if it be a globe or bottle, the liquid is poured in as high as it is desired to form the deposit. As soon as the heat, which must be applied, shows 50° Centigrade, the separation of the silver begins and soon spreads itself over the whole surface. At first, when the coating is very thin, it looks dark, but soon assumes a metallic luster ; when it is a brilliant white, it is time to remove the fluid contents, as the mirror is apt to be injured by too long contact with the aldehyde.

Flat objects are laid upon the mixture in the usual manner.

In Germany, where aldehyde ammonia can be purchased at a reasonable cost, this process is highly prized. By making his own salt, in the manner described above, the chemist in this country can also avail himself of the method.

Drayton's method is to employ a silvering fluid made of nitrate of silver, ammonia, and an alcoholic solution of the oil of cassia. This is poured upon the glass, and a reducing fluid of alcohol and oil of cloves applied. This causes a separation of the silver, which deposits itself upon the glass.

Vohl's method of silvering the interior of globes is to cause a precipitation of nitrate of silver by the use of a solution of gun-cotton dissolved in hot caustic potash.

Steinheil uses nitrate of silver, caustic ammonia, caustic soda, milk, sugar, and water. The deposit is pure silver.

Thomson's method, used mostly for silvering the inside of globes and bottles, deposits from an oxide or salt of silver.

Martin's process is quite similar to the last mentioned.

Some looking-glasses have a dark varnish or coating at the back. These reflect only a small portion of the light.

M. Salvetat has announced to the Society of Encouragement, in Paris, a process of preparing looking-glasses, in which tin-foil is replaced by platinum applied in a metallic and brilliant powder. The glass, having been carefully cleaned and polished, is covered, by means of a brush, with a mixture of chloride of platinum, essence of lavender, and a composition of litharge and borate of lead. When dry, the glass is placed in muffles, when the essence, being volatilized, leaves a deposit of platinum dust firmly united to the glass. The new process requires but a few hours. See PLATINIZING.

Dode's plan is to dissolve platinum in nitro-muriatic acid, evaporate to dryness, mix with oil of lavender, take the resulting precipitate, mix with litharge or borate of lead, apply to the glass and bake in an oven.

Lool. (*Metallurgy.*) A vessel to receive the washing of metallic ores.

Loom. A machine in which yarn or thread is woven into fabric.

A woven fabric consists of yarns called the warp laid in one direction, and crossed by yarns laid transversely and known as the *woof*. The *warp* is also called the *chain*. The words *woof*, *weft*, *filling*, are synonyms.

The essential parts of a loom are, —

1. A frame in which the row of yarns forming the warp is held.

2. Leashes or harness which govern the decussation of the threads to form a shed for the *woof*.

Means for holding and actuating, when of the simplest description, may be said to be a *yarn-beam*, to pay off the yarn as the weaving proceeds ; a means for operating the *leashes*, by which alternate threads all across the warp are raised and their intermediates lowered, so as to make a decussation (Lat., *decussis* = *decem asses* or X) or crossing known as the *shed*, in which the *woof* is deposited ; a means for holding taut the web, so as to keep a proper strain on the warp. A *shuttle* or bobbin for the yarn is usual, but this is not absolute, as a ball of yarn or other filling can be, and is, rolled through the shed. In horsehair and slat looms, the stiff filling is drawn through by fingers, or thrust through, and in some narrow-ware and fringe looms the filling is put in by a rod which goes and returns.

Stripped of its familiarity, weaving is a very ingenious and remarkable process, and many must have been the essays before a serviceable fabric was produced. The preparation of the fiber, its spinning, winding, warping, and weaving, must have had a gradual growth, but with the commencement of historical notices of civilization we find nations in possession of the art.

Egypt excelled in fine linen for ages before Abraham ; and the inhabitants of India doubtless spun and wove their cotton before Osymandyas, whose

> "Vast and trunkless legs of stone
> Stand in the desert."

It is natural to conclude that the plants which yielded fiber in bolls, such as the cotton and asclepias, were the first to be utilized, as the uses of flax, hemp, and silk require peculiar preparatory processes. Bark, although used extensively by the natives of some of the islands of Polynesia, has not come into general use for raiment elsewhere ; but few trees yield a bark which will make clothing equal to the *tapa* cloth of the Fijis. This is made from the paper mulberry, which grows wild in Oceanica and Polynesia, as well as in parts of Asia. The Fiji group is near the equator, and was discovered in 1643 by Tasman, the Dutch navigator. There are 225 islands, 80 of which are inhabited by a population estimated at 250,000. Paper is also made of the same material (Broussonetia), and specimens are in the Patent Office and Agricultural Department Museum.

The *masi* cloth is made by the same islanders, of the bark of the *malo*-tree. The bark, as removed from the tree, is steeped in water, and beaten on a flat log with a grooved mallet. Two lengths of the wet stuff are beaten together at their edges, being

united by their gluten. Separate pieces are united by the starch of the *taro* and then dyed. The mode of uniting is exactly the same as that practiced with the strips of papyrus, as described by Pliny. See PAPER.

The Fijis are strangely cruel, ingenious, and versatile, being the manufacturers for the islanders of other groups, supplying them with canoes, spars, sails, pottery, mosquito curtains, cloth, *sinnet*, rope of *coir* or cocoa-nut husk.

In Captain Cook's time the inhabitants of the Pacific islands had no knowledge of *weaving*, though ingenious in *braiding*, *plaiting*, and *netting*.

Perhaps the earliest examples of weaving were baskets, hurdles, and mats, in which the intersections are exactly the same, though the mode of production is different.

The invention of the loom antedates all authentic history of the Chinese, Hindoos, and Egyptians, and chance references to woven goods are found at an early period of the Old Testament history, as in the case of the "vestures of fine linen" in which Joseph was arrayed by Pharaoh. (See FLAX; LINEN.) The references to woven goods in the Mosaic period are very numerous. The art of weaving was held to have been derived from the early sovereigns of the land; so great regard was felt for the inventor, that the work was generally thus associated.

Semiramis, the Assyrian queen, is credited with the invention of weaving. The Greeks represented Minerva with a distaff, as being the inventress of spinning. Homer refers to the products of the loom. The Egyptians credited it to Isis; the Mohammedans to a son of Japhet; the Chinese to the consort of the Emperor Yao (Noah); the Peruvians to Mamaoella, wife of Manco Capac, their first sovereign.

The modern Arabs and the Hindoos use a procumbent loom. The Bible notices of weaving refer to *loom-work*, *netting*, and *braiding*. 1. When Delilah wove into the web the seven locks of Samson's hair.

2. Where Isaiah pronounces a curse upon Egypt, which shall destroy all her vast works of irrigation and improvement, and "confound" those who live by weaving networks.

The Bible also refers to needlework and embroidery, in the mournful song of the mother of Sisera. See DAMASK.

The mode by which the weavers of India execute the *jamdanee* has been explained by Mr. Taylor as follows:—

"The Hindoo weavers place the pattern, drawn upon paper, below the warp, and range along the track of the woof a number of cut threads equal to the flowers or parts of the design to be made; then, with two small, fine-pointed bamboo sticks, they draw each of these threads between as many threads of the warp as may be equal to the width of the figure which is to be formed. When all the threads have been brought between the warp, they are drawn close by a stroke of the lay or batten; the shuttle is then passed by one of the weavers through the shed, and the weft having been driven home, it is returned by the other weaver."

Pliny accorded the invention of the loom to the Egyptians. The Israelites carried with them the art of weaving when they left Egypt, and in Leviticus (chap. xiii.) the warp and the woof of linen and woolen fabrics are fairly distinguished.

The finest of the linen mummy-cloths of the ancient Egyptians — specimens of which may still be found — have about 140 threads to the inch in the weft and about 64 in the warp.

The looms of Egypt are shown abundantly in the tombs, and the web was either horizontal or perpendicular; the former are shown at Beni Hassan, the latter at Thebes. The woof was sometimes pushed upward, sometimes downward. The product was check or plain. The shuttle was not usual, but the filling was pushed through the shed by a stick or hooked rod. Wilkinson says that some of the colored patterns of the Egyptian cloths were worked by the loom; and others are the result of dyeing and printing processes.

"Colored dresses," says Pliny, "were known in the time of Homer, from whom the robes of triumph were borrowed; and from the Phrygians having been the first to devise the method of giving the same effect with the needle, they have been called 'Phrygiones.' But to weave cloth with gold thread was the invention of an Asiatic king, Attalus, from whom the name 'Attalic' was derived; and the Babylonians were most noted for their skill in weaving cloths of various colors."

It reminds one of the "prey of divers colors of needlework on both sides," in the famous Hebrew song more than thirteen centuries before Pliny, and of the "goodly Babylonish garment" secreted by Achan from the spoils of Ai, 1,500 years before the erudite Roman made his miscellaneous collection of curiosities.

A specimen of an ancient Egyptian rug in the possession of Mr. Hays is described by Wilkinson as made of woolen threads on linen strings, having a central figure in white on a green ground, a border of red and blue lines, and the remainder of it a ground of yellow with figures and ornaments in red, white, and blue. This is but 11 × 9 inches, and may be needlework on linen canvas, with one set of linen strings pulled out, and it cannot be relied upon as illustrative of *loom-work*, though interesting as *embroidery*.

Rugs and mats were the earliest form of carpets, and the early notices of them are frequent and interesting. (See CARPET.) Pliny says:—

"Thick flocky wool has been esteemed for the manufacture of carpets from the very earliest times. It is quite clear from what we read in Homer, that they were in use in his time. The Gauls embroidered them in a different manner from that which is practiced by the Parthians. Wool is compressed, also, for making a felt, which, if soaked in vinegar, is capable of resisting iron even; and, what is still more, after having gone through the last process, wool will even resist fire; the refuse, too, when taken out of the vat of the scourer, is used for making mattresses, an invention, I fancy, of the Gauls." "The *gausapa* [a thick cloth, shaggy on one side, and used for coverlets and cloaks] has been brought into use in my father's memory, and I myself recollect the *amphimalla* [napped on both sides] and the long shaggy apron [*ventrale*] being introduced; but at the present day, the *laticlave* [broad-striped] tunic is beginning to be manufactured into an imitation of the *gausapa*."

"Varro [50 B. C.] informs us that he himself was an eyewitness that, in the temple of Sancus, the wool was still preserved on the distaff and spindle of Tanaquil [wife of Tarquinius Priscus, 616 B. C., and a native of Etruria], who was also called Caia Cæcilia; and he says that the royal waved [watered] toga formerly worn by Servius Tullius [578 B. C.], and now in the temple of Fortuna, was made by her. Tanaquil was the first who wove the straight tunic [*tunica recta*, woven in a perpendicular loom]. Such as our young people wear with the white toga; newly married women, also. Waved [*undulata*, watered] garments were first the most esteemed of all, after

which those formed of various colors came into vogue. Fenestella informs us that togas with a smooth surface, as well as the Phrygian togas, began to be used in the latter part of the reign of Augustus. The *pretexta* had its origin among the Etrurians."

"The method of weaving with more than one thread was invented at Alexandria. These cloths are called *polimita;* it was in Gaul that they were first divided into checkers."

Pliny gives the Gauls good credit, — checker-work weaving, the reaping-machine, beer of malt, bread raised by yeast, sieves of horsehair, embroidered rugs; but all *trans Padanus* (Po) seems to have been Gaul with Pliny.

The Greeks and Romans had looms in which the warp was horizontal, and others in which it was vertical, so that the weaver *sat* at work. The box-wood shuttle was of the modern shape, pointed at each end, and had a cavity in which the woof-thread was wound on a stationary pirn or quill, or on a bobbin which revolved as the yarn unwound, and passed through a hole in the side of the shuttle.

The threads of the warp were decussated by a stick (*arundo*), which divided the threads alternately, and the respective sets were passed through the loops of the leashes (*liciæ*) of the harness; the leashes of a given set being attached to a straight rod called a *liciatorium*. The simplest form had one set of leashes, which alternately raised and depressed its set of threads above and below the intervening threads. The number of sets of leashes was increased according to the complexity of the pattern. The woof-thread was beaten up to compact the fabric by a sword (*spatha*) or a comb (*pecten*), like the modern *reed*.

The term *polimita*, signifying "many leashes," and the reference to it by Pliny, indicate that the Greek and Roman looms had harness in which the leashes were arranged in sets to weave twills or patterns, which the Latin terms *bilex*, *trilex*, and the Greek *dimitos*, *trinitos*, *polimitos*, alluding to the degree of complexity of the system, fully confirm.

What the Gr. ἑξάμιτον, or *six-threaded*, may have been it is not easy to tell; but the word is used in connection with a sprig or ornament produced in the texture at regular intervals, and it is probable that it was a six-part harness, floating the woof to make a pattern. The name came down through the ages as ξάμιτον, Lat. *samitum*, O. Fr. *samet*, Ger. *sammet*, Sp. *xamete*, It. *sciamito*, and in our own archaic, —

> "So flashed and fell the brand Excalibur:
> But ere he dipt the surface, rose an arm
> Clothed in white *samite*, mystic, wonderful,
> And caught him by the hilt."

The arts of dressing flax and wool were known in Britain previous to the conquest by Cæsar, who states that the art of weaving was not known by the islanders. However this may be, an imperial manufactory of woolen and linen cloth for the use of the Roman army in Britain was established at Venta Bulgarum, since called Winchester. In Bishop Aldhelm's book, A. D. 680, in an essay on character, occurs a simile from the art of figure-weaving, in which he refers to a "web woven by shuttles, filled with threads of purple and many other colors, flying from side to side, and forming a variety of figures and images." A famous specimen of embroidery of this character is preserved in the Cathedral of Bayeaux. It is a piece of linen about 19 inches in width and 67 yards in length, containing the history of the conquest of England by William of Normandy. It is supposed to have been executed by Matilda, wife of William, and the ladies of her court. Its beauty is principally needlework.

The annexed cut is from Erasmus's book, the "Praise of Folly," and shows the lady of the house

Fig 2996.

A Ladye at her Loom.

at her loom. The cloth-beam, shuttle, and harness are clearly shown.

> "What need we name the sev'ral kinds of looms?
> Those delicate, to whose fair-colour'd threads
> Hang figur'd weights, whose various numbers guide
> The artist's hand: he, unseen flow'rs, and trees,
> And vales, and azure hills, unerring works."
>
> DYER, *The Fleece*, 1757.

Toward the close of the eleventh century, the weavers in the large towns of England were formed into guilds or societies.

In the reign of Richard I. (1197) a law was passed for regulating the fabrication and sale of cloth.

Edward III. encouraged the immigration of weavers and cloth-makers, but the art does not seem to have flourished in England as it did on the Continent, as wool continued to be a staple article of export.

During the persecutions of the Duke of Alva in Flanders, in the sixteenth century, many Flemish weavers settled in England, and introduced or promoted the manufacture of baizes, serges, crapes, and other descriptions of stuffs. The revocation of the Edict of Nantes in 1685 (granted to the French Protestants by Henry IV. in 1598, confirmed by Louis XIII. in 1610, and by Louis XIV. in 1652), by Louis XIV. drove from France many ingenious artisans, who carried with them to England and other countries the arts of silk working, making crystal glass, jewelry, etc.

In weaving plain cloth the threads which run lengthwise of the fabric constitute the *warp*. Those in the direction of the width are called the *weft*, *woof*, *shoot*, or *tram*.

The warp is divided into two parts, each containing an alternate thread, which are alternately raised and lowered, allowing the weft-thread to pass between them through a space termed the *shed*.

The principal working parts of the hand and power loom are the same, comprising a frame, at one end of which is the *beam* or *yarn roll*, on which the warp-threads are wound, and at the other the *cloth-beam* on which the finished cloth is wound. The means for paying off the yarn from one beam and winding the cloth on to the other are known as the *let-off* and *take-up* respectively.

Each half of the warp is alternately raised and lowered by means of the *healds* or *heddles*, threads

having loops at their lower ends and attached above to two horizontal rods connected by a pulley, the whole collectively constituting the *harness*, so that when one heald rises the other falls. Each warp-thread passes through one of these loops. The warp-threads also pass through the *dents* or teeth of a *reed* at the lower part of a movable swing-frame called the *lathe*, *lay*, or *batten*, which beats home and compacts the warp-threads as the work progresses.

The bottom of this frame has a projecting ledge, forming a path for the *shuttle* which contains a *cop*, on which the weft-yarn is wound.

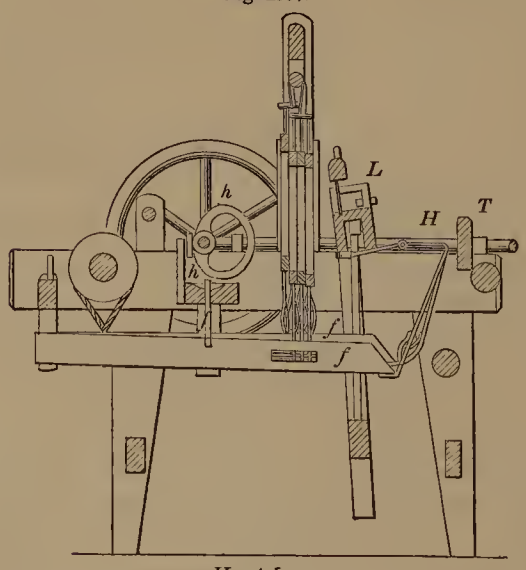
The shuttle in hand-looms is thrown across the race by hand or by means of the *fly*. When the latter is used the two ends of the shuttle-race are closed, so as to form a trough in which two pieces of wood, called *pickers* or *peckers*, are caused to move along wires. A string from each picker is attached to a handle which the weaver holds in his right hand, and by means of a smart jerk he propels the shuttle back and forth along the race. The weaver is seated at the end of the loom next the cloth-beam, and by pressing with his foot on one of two treadles he raises one of the *healds*, and with it one set of warp-threads. The shuttle is then thrown, passing through the shed between the two sets, and the weft-thread is driven home by the batten, which the weaver guides with his left hand. The other treadle is now depressed, raising the other set of warp-threads, the shuttle thrown back to its first position and the weft-thread beaten home as before. In this manner the weft-thread is caused to pass alternately above and below the threads of each of the two sets composing the warp until the work is completed. When a few inches of cloth are woven it is wound upon the cloth-beam.

In order to prevent the cloth from contracting in breadth before being wound on the cloth-beam, two pieces of wood with sharp-pointed ends, which are inserted in the selvage of the cloth, are employed. This stretcher is called a *temple*.

Previous to being wound on the yarn-beam, the warp-yarns require to be laid side by side in one plane. This is effected by a device called the WARPING-MILL (which see).

In Fig. 2997 is shown an improved hand-loom,

Fig. 2997.



Hand-Loom.

operated by a crank on the shaft *H*. The warp-roller is at the left and the cloth-roller at the right of the machine. The harness-frame carries four heddles, which are actuated by the revolution of the cams *h h*, acting on levers *f f* connected to the heddles. *L* is the shuttle-box on the lay, and *T* the breast-beam. A fly-wheel on the same shaft with the cams equalizes the motion. The cams are so arranged on the shaft as to act in the required consecution to produce the twill or pattern required, and by increasing the number of cams and heddles a variegated recurrent pattern of considerable complexity may be produced. The revolution of the crank gives all the motions of the machine, — heddles, shuttle, and batten. (See HAND-LOOM.) In other forms of hand-looms the motions are derived from the vibration of the batten.

A positive motion has been given to the shuttle in place of the fly motion, on several occasions. Once in Greenough's circular loom, and again in Lyall's reciprocating loom. In the latter case, the shuttle is conveyed through the shed by a carriage which is impelled by cords, which are wound upon a reciprocating drum beneath the frame. The carriage and the shuttle have rollers which move in contact with the yarn, so as to have a rolling but no rubbing action. The rotary motion of the rollers in the carriage is transmitted through the warp to the lower rollers of the shuttle, as the threads of the warp pass between the two.

The earliest power-loom on record was contrived by a French naval officer, M. de Gennes, and is described in the "Journal des Sçavans," 1678. The inventor claimed that a single mill could give motion to 10 or 12 looms, and that cloth could be made by their means much wider than by the ordinary loom then in use. It does not appear to have been a practical working apparatus, and never came into use.

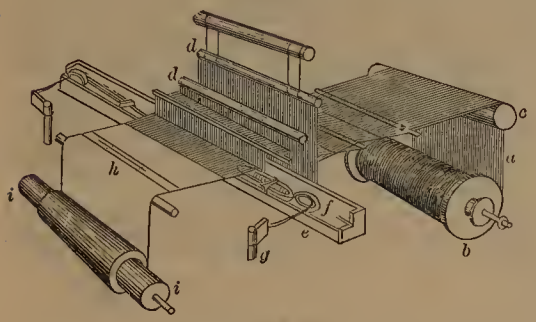
We are indebted to Dr. Edmund Cartwright for the first practical power-loom. He was a minister of the gospel, and unacquainted with mechanics; but had his attention turned to the subject by a remark, that when Arkwright's patents expired so many persons would go into the spinning business that no hands would be found to weave the cotton. He declares that his first attempt was a most rude piece of machinery. "The warp was placed perpendicularly, the reed fell with the weight of at least half a hundred weight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket." It required the power of two men to work it. He secured his patent April 4, 1785. He then went for the first time to see how other people wove, and was astonished at the comparative clumsiness of his own contrivance. He went on improving, and took out his last patent 1787. He met with the trouble incident to great inventors, — an ignorant populace and rich pirates. He spent £30,000 in his endeavors to perfect his loom, and in 1808 received a Parliamentary grant of £10,000 for his great national services. On this sum he retired to a farm in Kent, and spent his declining years in comfort, occasionally trotting out his hobbies. He died in 1823, aged 80.

Steam was applied to his looms in 1807.

Fig. 2998 shows the working parts of a power-loom, the framing being omitted.

The warp *a* is wound upon the warp-beam *b*, and, passing over the roller *c*, is carried through the two healds *d d*, which alternately raise and lower the two sets of warp-threads, forming the shed for the passage of the shuttle. The shuttle is driven along the shuttle-race *e* by a kind of hammer *f*, worked by a lever *g* moving through a small arc of a circle. The finished cloth is kept tight by the temples *h*, a portion being wound on the cloth-beam *i i*.

Fig. 2998.



Working Parts of a Power-Loom.

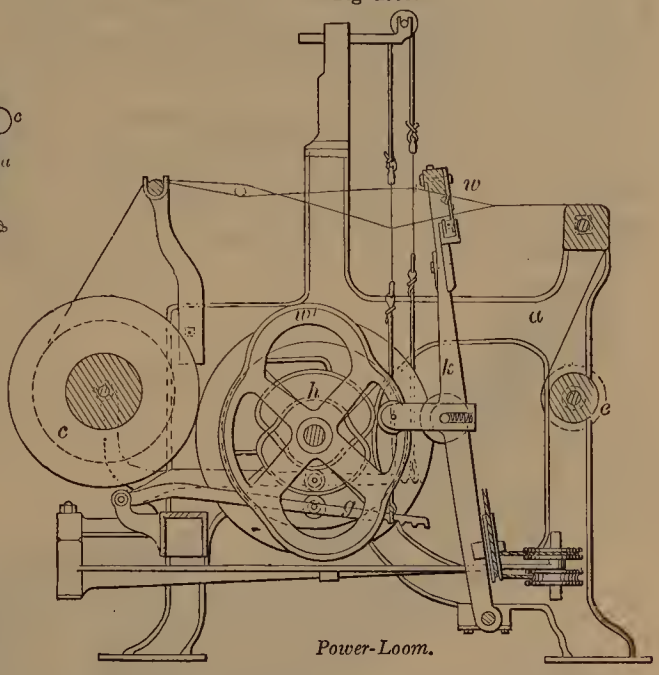
In the power-loom, five distinct actions are performed by steam-power.

1. Raising and lowering alternately the two sets of warp-threads.
2. Throwing the shuttle.
3. Driving up each weft-thread after the shuttle is thrown.
4. Unwinding the warp from the beam.
5. Winding the cloth on the cloth-roller.

An arrangement is also introduced for stopping the loom when a thread breaks, when the shuttle sticks in its passage, or when the yarn on the cop contained in the shuttle has run out. This may be effected in various ways, depending on the nature of the loom.

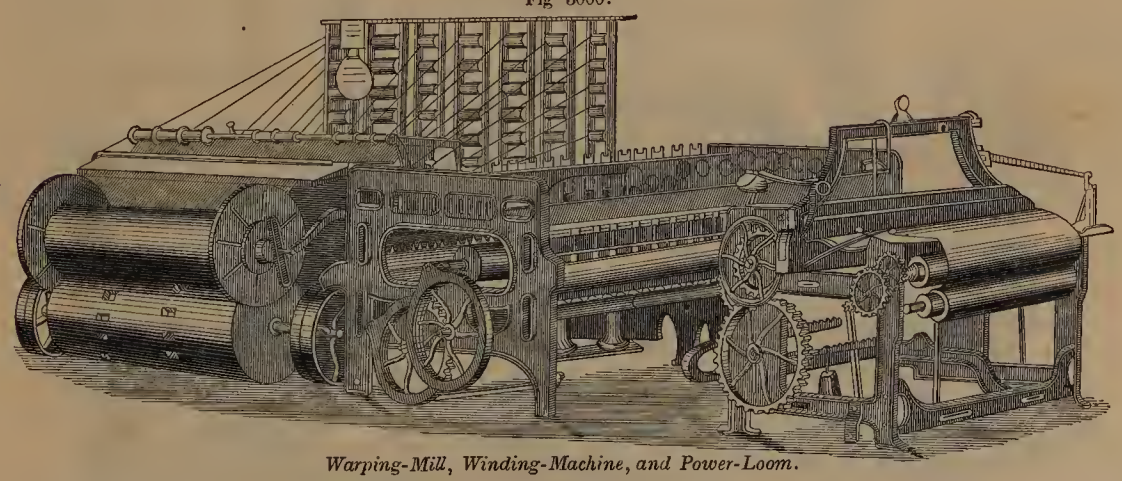
Fig. 2999 represents an improved power-loom. *a* is the frame, *c* is the warp-beam, and *e* the cloth-beam; *k w*, the lay. The heddles are actuated by cams *h* acting on the levers *g*, to which they are connected. On the same shaft is the scroll-cam *w'*, in which traverses a roller imparting a vibratory motion to the lay, in which is a raceway for the shuttle.

Fig. 2999.



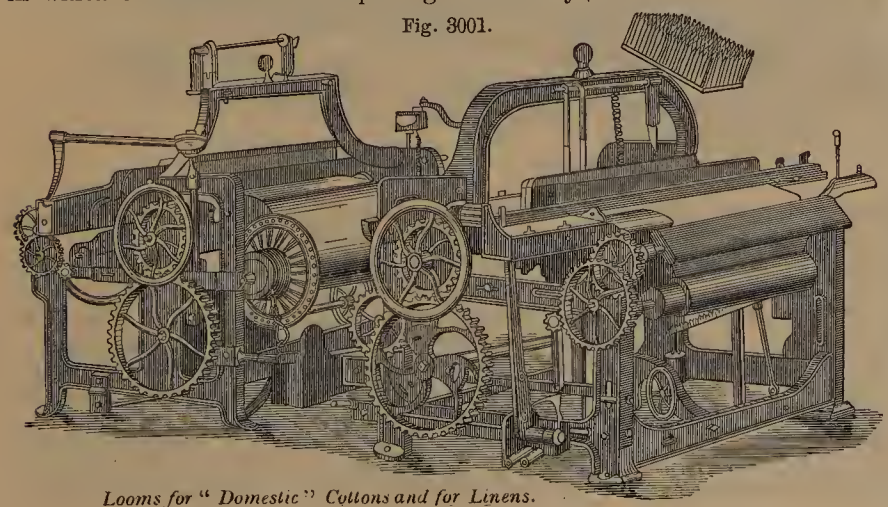
Power-Loom.

Fig 3000.



Warping-Mill, Winding-Machine, and Power-Loom.

Fig. 3001.



Looms for "Domestic" Cottons and for Linens.

Fig. 3000 is a perspective view of a *warping-machine*, *winding-machine*, and a *loom* for light and medium cotton goods.

Fig. 3001 is a perspective view of two looms, one for "domestics" and heavy cotton goods, the other, on the right of the picture, for linens.

With the modern power-loom, the cost at Manchester of weaving a piece of cotton cloth 25 inches wide, 29 yards long, and 11 picks per ¼ inch, is estimated at 10¼ cents. One person can attend

to two or three looms, and each loom produces 26 pieces of such cloth per day.

On the old hand-loom of 1800, one man would attend to one loom, and would produce 4 pieces at an expense of 66 cents each.

In plain cloths the warp and weft threads are of about equal fineness. Yarns of two different sizes introduced into the web produce a sort of striping. When the warp and weft threads are of different colors a shot pattern is produced.

Striped patterns are formed by introducing at regular intervals the different colored threads required; checks, by inserting different colored threads at proper distances in the warp and crossing them in the weft by threads of the desired color in sufficient number to give the desired width.

In twills, each weft-thread does not cross alternate warp-threads, but only the recurrent third, fourth, fifth, or sixth, the required number being inserted through each heald. See TWILL.

Piled work, as velvet, velveteen, fustian, or piled carpet, is formed by introducing a third thread, previ-

Fig. 3002.

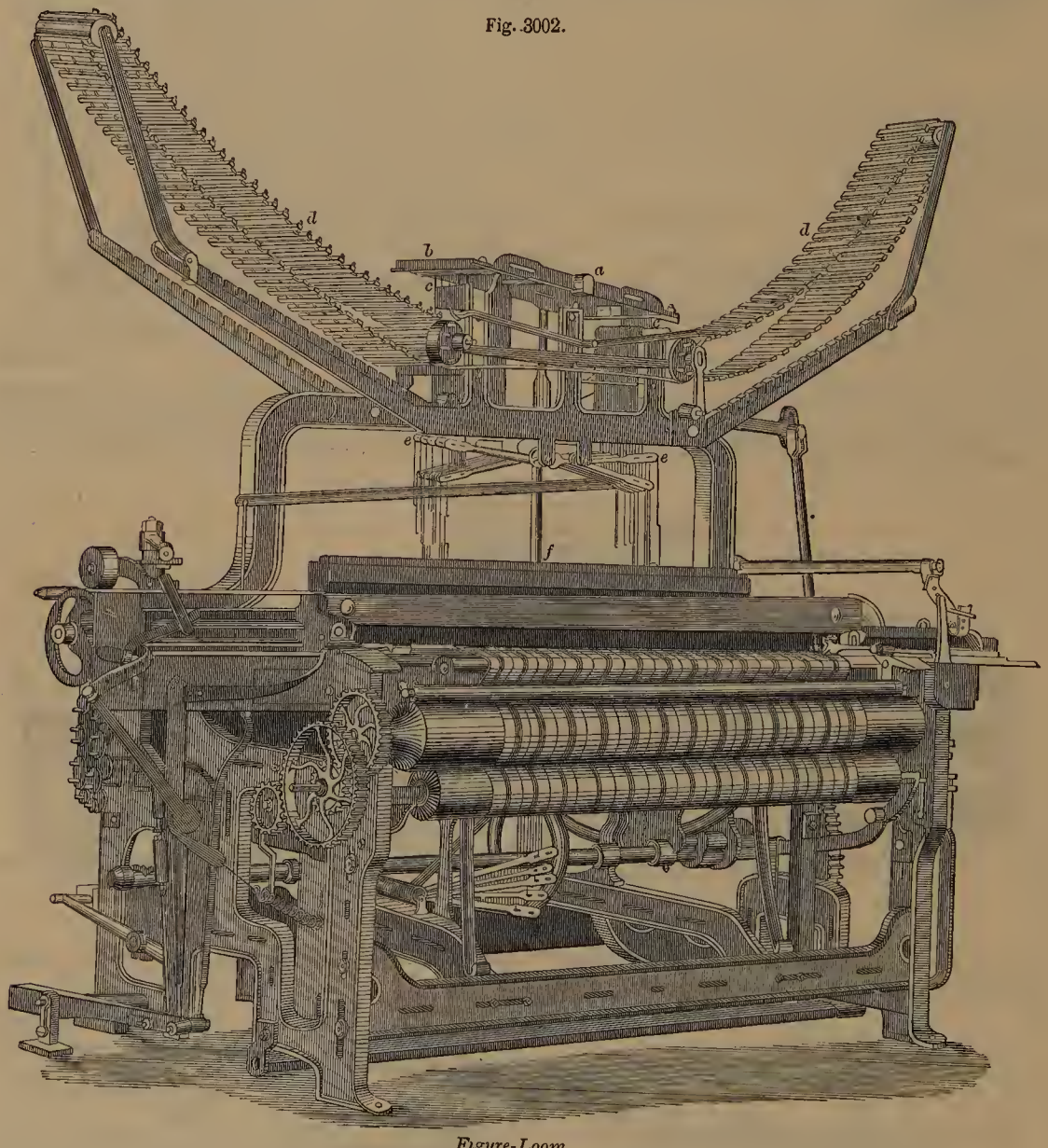


Figure-Loom.

ously looped by weaving it over wires the breadth of the fabric. In some kinds these are cut out with a knife, in others they are simply withdrawn from the loops.

One mode of making goods in patterns of colored figures is by means of a variety of shuttles, each carrying its own colored thread. These shuttles are arranged in a box which may be raised or lowered, so as to bring the required shuttle opposite to the picker which drives through the shed. This motion of the shuttle-box is obtained by means of a PATTERN-WHEEL or PATTERN-CHAIN (which see).

Figures, previous to the invention of Jacquard, were formed in the *draw-loom*.

In this, the warp-threads were arranged in separate groups so disposed as, in conjunction with the weft-threads, to form the figures. The proper succession of the weft-threads as to color, etc., was arranged by the weaver, several shuttles being employed, if necessary. For this purpose, a pattern-card was provided, to which the workman could constantly refer. Each set of warp-threads was attached to a handle by which they were drawn up at the proper time by an attendant called a *draw-*

boy. This involved liability to mistakes, deranging the pattern, and to obviate this a mechanical draw-boy was invented.

Jacquard's ingenious invention superseded this, producing an entire revolution in the art of figure-weaving.

Joseph Maria Jacquard was born at Lyons, 1752; invented his loom for weaving figured fabrics in 1801; and died at Orleans in 1834.

The action of the Jacquard in producing patterns upon fabric may be briefly described as follows: —

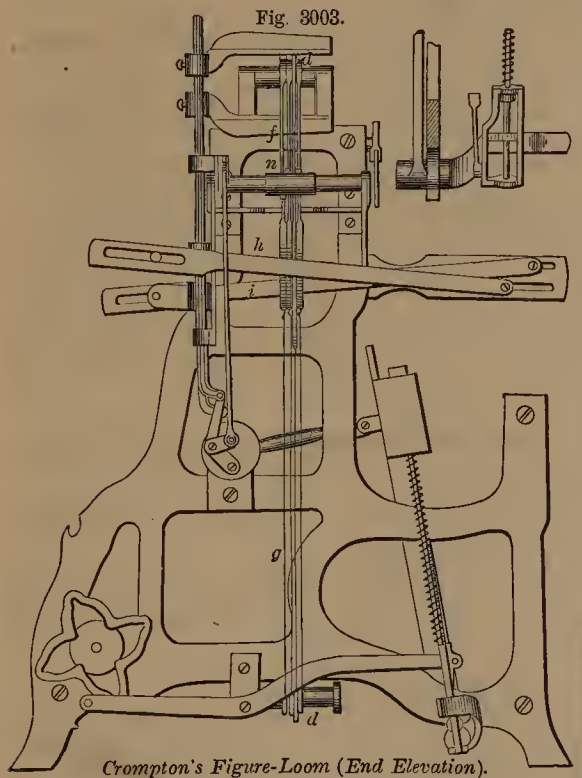
To the ordinary looms perforated cards are added, through which certain needles pass, causing the threads to rise and fall, according to the holes in the cards, thus reproducing upon the tissue in the loom the pattern which is perforated in the card. See JACQUARD LOOM.

Fig. 3002 is a view of an English power-loom for fancy weaving, having what is called a *dobby*, with the harness controlling mechanism.

The pattern-chains *d* are mounted in a frame at the top of the loom, and in their movement their pins act on vertical hooked wires or jacks *c*, connected with a series of coupled levers *e*, connected in turn with the harness-frames *f*. A rocking frame *a* at the top of the loom, provided at its opposite ends with cross or griff knives or bars *b*, engages the hooked wires selected by the pins of the pattern-chains, and raises the harness-frames necessary to produce the pattern. Plain and fancy twills, spots, satin checks, etc., may be produced. The loom also shows changeable shuttle-boxes.

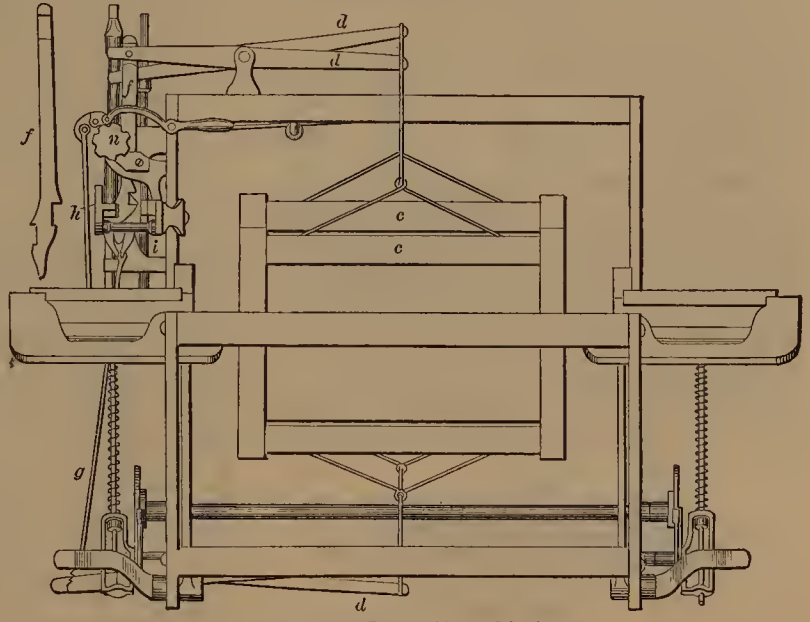
One example of Crompton's looms is given in Figs. 3003 and 3004, the former being an end elevation and the latter a front elevation.

Fig. 3003.



Crompton's Figure-Loom (End Elevation).

Fig. 3004.

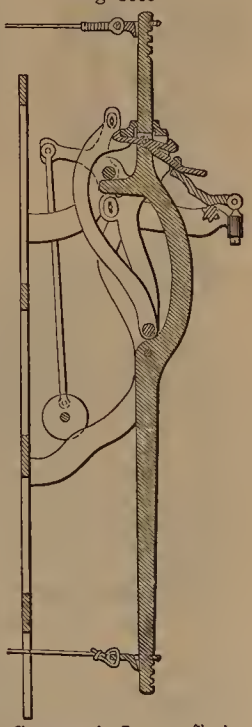


Crompton's Loom (Front View).

The harness-frames *c* are attached by cords or wires to horizontal top and bottom levers *d*, whose opposite ends are connected by means of notched jacks *f* and wires *g*. The notched jacks are moved by pins on a pattern-cylinder *n*, so that their notches are engaged by either the lifter or depresser *h i*, to raise or lower the harness-frames. This loom has also shifting shuttle-boxes, and the box-lever is moved by a star cam.

On the left of Fig. 3004, one of the jacks *f* is shown on an enlarged scale to exhibit the notches more clearly.

Fig. 3005.



Crompton's Loom (Shedding Motion).

In another variety of Crompton's loom (Fig. 3005), vertical levers pivoted at the side are connected at bottom and top to the heddle or harness-frames by cords, and notched jacks pivoted to such vertical levers and controlled by a pattern-cylinder are engaged by bars which move the levers and open the shed, these bars acting as lifters, depressers, and eveners. The figure shows the motion work merely.

In Short's loom for weaving fabrics of any width, the shuttles are carried through the shed by a belt having a continuous motion. This is supported on a carriage with small anti-friction rollers traversing the raceway when it is swung as a batten. A shuttle is engaged by a lug on the belt, and, after crossing the shed, deposited in a chan-

nel in the frame, when the belt engages another shuttle and carries it across in the opposite direction.

The number of patented inventions relating to looms and their appliances, both in this country and England, many of them of slight importance, is too great to give even a brief idea of here. Some of the more important will be found under their specific heads. See WEAVING.

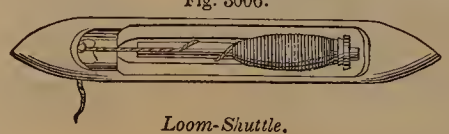
2. (*Nautical.*) The part of the length of an oar inside the gunwale in rowing. In contradistinction to the *blade*.

Loom-card. (*Weaving.*) A pierced pattern-card for Jacquard weaving.

Loom-har'ness. (*Weaving.*) That portion of the loom by which the warp-threads are moved to make the decussation, forming the shed in which the shuttle travels and leaves the weft-thread. The harness has heddles with loops for the warps, and a part are raised above the others, either in regular alternation for plain weaving, or in other order, according to the pattern. See LOOM; TWILL.

Loom-shut'tle. One for carrying the *weft*-thread through the *shed* formed by the decussation of the warp. An orifice is made through the shuttle

Fig. 3006.



Loom-Shuttle.

in line with the yarn-eye, and another through the bottom at the same distance from the end. There are many varieties.

Loon'ghie. (*Fabric.*) A silk and cotton cloth of rich color, made in Sinde, in pieces about 4 yards long and 2 feet wide.

Loop. 1. (*Machinery.*) A slotted bar which forms a guide and limit to the motion of an object.

Fig. 3007.

Loops and Loop-Holders.

2. A sleeve or collar *a*, as that upon the middle of a neck-yoke.

3. (*Nautical.*) *e*, a bastard loop; a rope stopped with yarns.

f is a loop for slipping other lines, acting as a fair-leader.

g, a bend stopped with seizings.

4. A hinge of a door or gate.

5. A panel of bars joined together like a gate, to be removed in and out at pleasure.

6. (*Telegraphy.*) A wire going out and returning to the same point, as to a branch office, and forming a part of a main circuit.

7. (*Metallurgy.*) A mass of iron gathered into a ball on the floor of a reverberatory furnace, and in a pasty condition ready for the tilt-hammer or rolls.

It is conveyed by dragging on the iron plates which form a track on the floor, or in a little truck called a *ball-trolly*. A *loup*.

Loop'er. A perforated blade or bodkin for inserting the end of a carpet-rag through the end of another piece, looping them together to avoid the trouble of sewing.

Loop-hold'er. A carriage-iron (*b c d*, Fig. 3007) by which the *loop* of a strap is attached to running-gear or the bed.

Loop-hole. (*Fortification.*) An aperture or slit in a stockade or other defense, from whence musketry may be fired at assailants. Machiolation, embattlement, embrasure, crenelle.

Loop-line. 1. (*Railway Engineering.*) A connecting line of railway; one running into the trunk.

2. (*Telegraphy.*) A wire going out and returning to the main circuit. A *loop*.

Loos'en-ing-bar. (*Founding.*) A stiff bar with a point or screw which stands in a hole in the pattern, and extends upward through the top box. After ramming up, and before lifting the top part, this bar is struck alternately from opposite sides with a short, heavy piece of iron, so as to loosen the pattern slightly in the sand, after which it is removed. This operation facilitates the separation of the sand from the pattern, and lessens the amount of mending required. See MOLDING.

Loose-pul'ley. (*Machinery.*) A pulley running loosely on the shaft, and receiving the belt from the *fast-pulley* when the shaft is to be disconnected from the motor.

Lo'per. (*Rope-making.*) The swivel at the end of a ropewalk remote from the *whirl*, and to which the ends of the yarns are attached when laying up several yarns into a rope. As the twisting proceeds, beginning at the remote end, the *top* which holds the strands apart is gradually advanced towards the *whirl*.

Lop'ping-axe. A light axe used for trimming trees. The term may be considered as in contradistinction to *felling-axe* or *logging-axe*.

Lop'ping-shears. A pair of heavy shears for trimming bushes, hedges, etc.

Lor'cha. (*Nautical.*) A light Chinese coaster having a hull of European model and Chinese masting and rigging.

Lor-gnette'. An opera or spy glass.

Lor'ry. A handcart used on tramways, in mines, or at railway stations.

Losh-hide. An oiled, undressed hide.

Lost-mo'tion. The difference in the motion of a driver and a driven part, owing to looseness of fit of boxes, the connecting portion, or slip of belt.

Lounge. A sofa with a back and one end.

Lou'vre. (*Architecture.*) *a.* A turret on a roof for the escape of smoke or steam. A *lantern*.

b. Sloping boards overlapping each other, with a space between for ventilation. Also called *luffer-boarding*; *louvre* or *luffer* window or work.

Low-bell. 1. A bell used to slightly alarm birds and cause them to lie quiet, until they are flushed by a sudden noise.

2. A *sheep-bell*.

Low-blast Fur'nace. A metallurgic furnace in which the air of the blast is delivered at moderate pressure.

Low'er An'chor. (*Nautical.*) One down stream for anchoring boats.

Low'er Case. (*Printing.*) *a.* The case standing below the upper case which contains the capitals, etc. The lower case has the small letters, the points, and some other sorts.

b. The letters belonging to said case.

Low'er Deck. See DECK.

Low'er-ing. (*Printing.*) A depression of the face of a type or woodcut to cause it to print lighter. The removal of the thickness of the tympan in the appropriate spots assists in producing the required effect.

Low-press'ure En'gine. (*Steam-engine.*) In

England, one in which *a condenser is used*, and whose safety-valve is loaded at from *four to six* pounds to the square inch. — LARDNER.

The terms *high* and *low pressure* steam were formerly held to mean saturated steam at a pressure above or below that which will sustain a column of thirty inches of mercury; the boiling heat of water, 212° of Fahrenheit.

The term *low pressure* signifies in this country a pressure of not over fifty pounds to the square inch.

Low-re-lief'. The slight prominence of a sculptured object from the plane surface to which it is attached. Also known as *basso-rilievo.*

Low'ry. (*Railway Engineering.*) An open box-car.

Low-wa'ter A-larm'. The devices for this purpose may be classed under four heads.

1. Those in which a float in the boiler subsides with the water, and is the means of opening a feed-valve, turning a steam-cock to the whistle, and indicating on a dial the condition of the boiler.

2. Those in which the subsidence of the water uncovers the end of a pipe, and admits steam to a rod or tube whose increment of heat and consequent expansion operate mechanically upon a valve, and allow steam to pass to a whistle.

3. Those in which steam admitted to a pipe, as just stated, melts a fusible plug, and so allows steam to pass to a whistle.

4. Those in which the subsidence of the water uncovers the end of a pipe and allows water to flow from a reservoir on the end of a lever, the steam from the boiler occupying the place thus vacated. The change of weight incident to the substitution causes the motion of a lever, which is made to open a valve or turn a stop-cock and emit steam to the alarm-whistle.

1. The *float movement.*

A. The float is attached to an arm, and is immersed in water in the chamber which communicates by pipes with the boiler. Should the end of the lower pipe be uncovered by the subsidence of the water to that level, the water leaves the chamber and the float falls, depressing the valve and admitting steam to the whistle. When the water rises again, the upper valve is moved to allow steam to depart, and the normal condition is re-established.

B. The hollow steam-tight case has a central hub and a sector space, occupied by the arm of a float, which rises and falls with the changes of level of the water in the boiler. An indicator on the same axis moves with the float.

C. A float is placed on the crank-arm of the valve-stem, and rises and falls with the changes of the water-level, bringing a stud on the stem against an inclined socket, and raising the valve from its seat. This allows steam to pass to the whistle.

2. The *thermostat movement.*

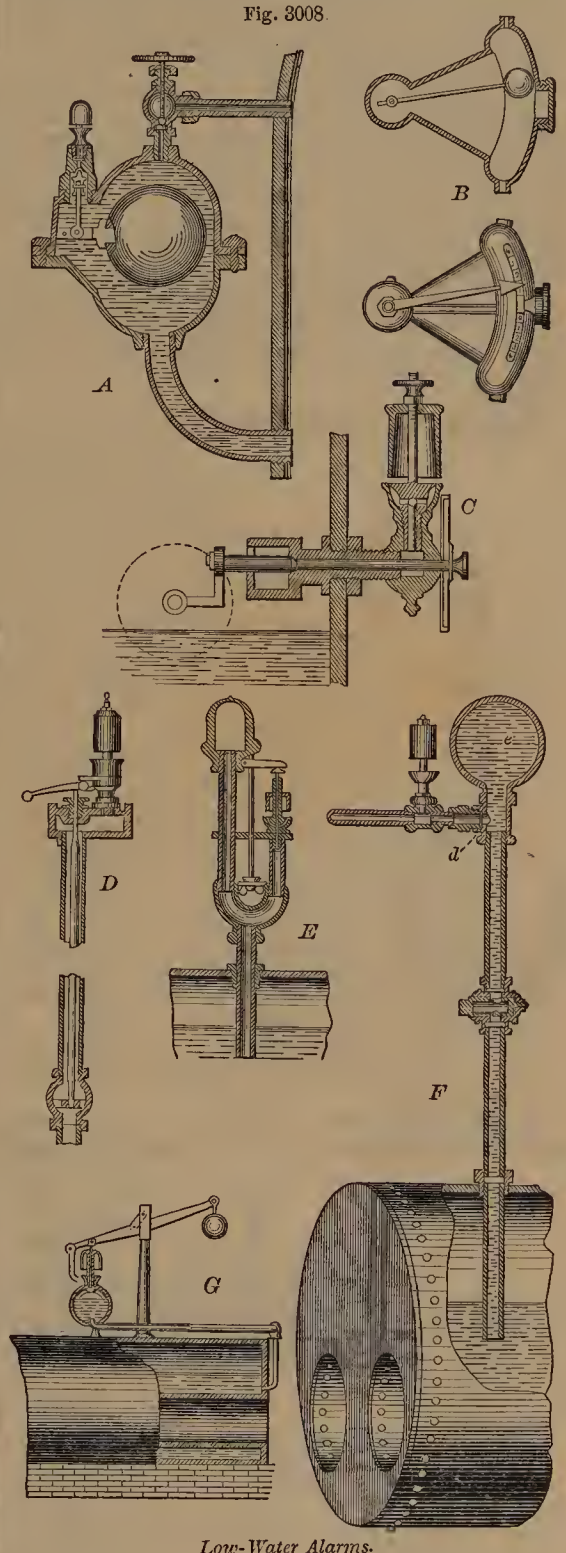
D. When the water subsides below the end of the vertical pipe, which extends downward into the boiler, the water contained therein is discharged and steam substituted. The increased heat, due to the presence of steam, elongates the thermostatic rod in the tube and acts upon the lever to lift the valve from its seat; the steam rushes out and sounds the whistle.

E. This acts similarly to the foregoing, except that the effect is due to the expansion of the steam-pipes when the water is emptied and steam admitted. The lever has its fulcrum on a post between the pipes; the expansion of one of the latter depresses the valve-stem and withdraws the valve from its seat; the expansion of the other pipe withdraws the seat from the valve. The action of the two is cumulative. The passage of steam sounds the whistle, as in other devices for the same purpose.

3. The *fusible-plug action.*

F. After the boiler has been filled to the water-line and put in operation, the pressure of the steam

Fig. 3008.



Low-Water Alarms.

forces the water into the pipe and air-chamber *e*. As there can be no circulation of water in the pipe as long as the lower end of it is under the water-line, the *disk d* will continue solid; but when the water in the boiler evaporates below the end of the pipe to

the alarm water-line, then the water in it falls of its own weight into the boiler, and steam at once takes its place, melts the plug, and notice of low water is given by the sounding of the whistle.

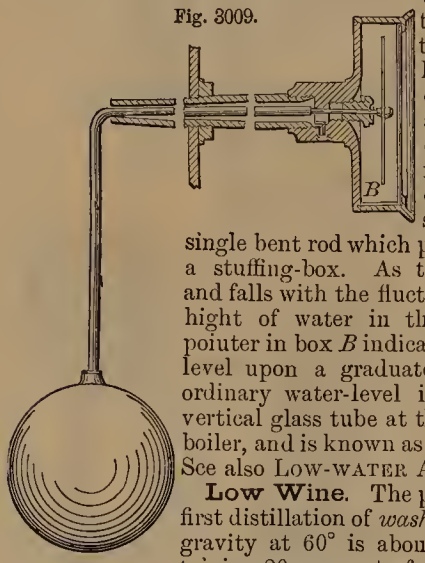
There are many variations of the fusible-plug device, some depending upon the direct heat of the steam, and others, as above, upon the admission of steam to a pipe which is normally charged with water.

4. The *gravity movement.*

G. A vertical pipe passes into the boiler, and its open end is at the level at which it is desired notice shall be given. This pipe forms a communication between the boiler and a reservoir on the end of a hollow arm and axis. In the normal condition this reservoir is filled with water; but when the end of the pipe is uncovered by the subsidence of the water-level in the boiler, the water runs out of the reservoir and steam takes its place. The change of weight in the reservoir, due to the substitution of steam for water, causes the arm to be lifted by the weighted lever and raise the valve which admits steam to the whistle.

Low-wa'ter In'di-ca-tor. An attachment to a boiler to show the depth of water in the boiler. It may, as in the example, be an arrangement of float and needle mounted upon opposite ends of a single bent rod which passes through a stuffing-box. As the float rises and falls with the fluctuations of the hight of water in the boiler, the pointer in box *B* indicates the water-level upon a graduated arc. The ordinary water-level indicator is a vertical glass tube at the end of the boiler, and is known as a *water-gage.* See also LOW-WATER ALARM.

Fig. 3009.



Low-Water Indicator.

Low Wine. The product of the first distillation of *wash.* Its specific gravity at 60° is about 0.978, containing 20 per cent of alcohol.

Loz'enge. 1. An oblique-angled parallelogram. A *rhomb.* A *diamond.*

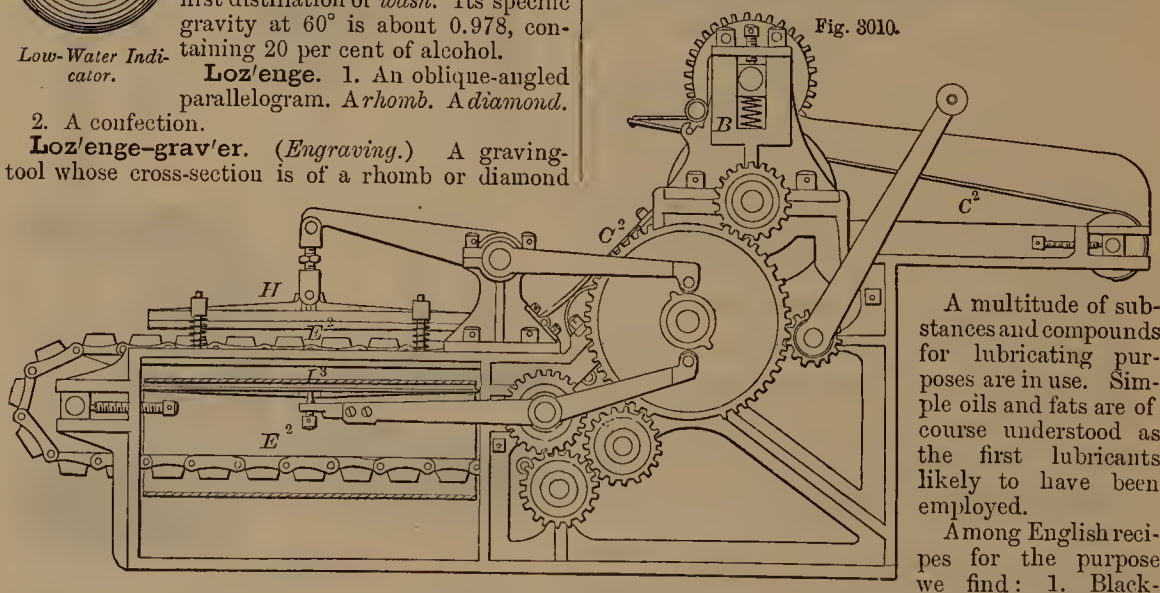
2. A confection.

Loz'enge-grav'er. (*Engraving.*) A graving-tool whose cross-section is of a rhomb or diamond shape. The two faces which meet to form the belly of the graver have an angle less than 90°.

Loz'enge-ma-chine'. A machine for rolling out and cutting lozenges, crackers, etc.

In the machine shown in Fig. 3010, *dough* is rolled out to the required thickness by passing between rollers *B*, follows the endless band C^2, and passes over the perforated cutters E^2. Here the feed is stopped, and the platen *H* falls on the dough, forcing the lozenges down upon an endless belt I^3. When the platen rises, the unused *dough* is carried to the end of the machine by the forward motion of the cutters, and returned to the rolling-cylinders by an attendant.

Fig. 3010.



Lozenge-Machine.

Loz'enge-mold'ing. (*Architecture.*) An ornament inclosing diamond-shaped panels.

Lub'ber's-hole. (*Nautical.*) An opening in the floor of the *top* for those to crawl through who are afraid to climb up by the *futtock-shrouds.*

Lu'bri-cant. A substance used to diminish friction of the working parts of machinery.

According to M. Morin, the friction of a cast-iron shaft upon a dry bell-metal bearing amounts to nearly one fifth of the power transmitted, while with a wrought-iron shaft friction absorbs more than one fourth. When well lubricated, the loss is reduced to .065 and .09 respectively.

The requisites of a good lubricant are that it must endure the heat even of melted lead, without change, in order to stand friction and lubricate the cylinders of steam-engines. (The heat under a pressure of 150 pounds of steam is enough to decompose or distill and dry up most of the natural oils in market.) They must be fixed and not volatile oils, as produced by destructive distillation, otherwise they are decomposed by friction, and burnt or dried up. They must not show or possess any acid reaction, either naturally or artificially, otherwise the bolts are cut in the steam-chest, and the iron, particularly wrought-iron, is made porous. They must possess a sufficient power of tenacity without oxidation, otherwise they will gum.

The same laws are applicable to signal and burning oil, for it makes no difference whether the oil is subject to immediate heat, as in a lamp or steam-cylinder, or whether it is slow and long continued, as in slides and other bearings, the effect and result are the same in the end upon the oil.

A multitude of substances and compounds for lubricating purposes are in use. Simple oils and fats are of course understood as the first lubricants likely to have been employed.

Among English recipes for the purpose we find: 1. Black-lead, 1; tallow 4. Mix and grind perfectly smooth. Add beeswax for railroad carriages.

2. (Booth's.) Scotch soda, 1 pound; boiling water, 2 gallons; palm-oil or tallow, 10 pounds. Agitate till the mixture is cooled to 65° Fah.

3. (Mankettrick's.) Caoutchouc dissolved in oil of turpentine, 4 pounds; Scotch soda, 10 pounds; glue, 1 pound; dissolve in water, 10 gallons; oil, 10 gallons. Stir, adding caoutchouc last.

4. Rape-oil, 1 gallon; caoutchouc (cut small), 3 ounces. Dissolve with heat.

The following compounds have been used in America: —

Resin, flowers of sulphur, antimony, oil rosemary, lampblack, water, carbonate of iron, sheep's tallow.

Animal oil, palm-oil, paraffine.

Asbestus, graphite.

Palm-oil, tallow, borax, salt, water.

Soapstone, petroleum, sulphur, antimony, oil.

Lampblack, petroleum.

Coal-oil, isinglass, Irish moss, glue.

Caustic soda, tallow, petroleum, animal hair.

Paraffine, resin, cotton waste.

Tallow, sulphur, soapstone.

Petroleum, plumbago, beeswax, mutton-tallow, soda.

Lime, chalk, carbonate of potash.

Leather boiled in carbonate of soda, oil, sulphuric acid.

Water, salts of niter, sulphur, soft soap, salt pork.

Borax and oil.

Petroleum residuum, alkali, ammonia, saltpeter.

Graphite, oil, caoutchouc.

Asbestus and grease.

Lignum-vitæ, spermaceti.

Ivory dust, spermaceti.

Tin and petroleum.

Zinc and caoutchouc.

Plastic bronze and caoutchouc.

Boiling water, tallow, palm-oil, salts of tartar.

Oil, lime, graphite, castor-oil.

Shorts, soapstone, graphite.

Coal-oil residuum, chloride of sodium, hydrated potassa, muriate of ammonia, spirits turpentine, linseed-oil, flowers of sulphur.

Petroleum residuum and flour.

Petroleum residuum, soapstone, sulphur, and lard.

Mixed heavy and light petroleum.

Oil, wax, resin, india-rubber, potash.

Petroleum residuum, sal-soda, brimstone, kerosene.

Glycerine, graphite, asbestus, kaolin, manganese, steatite, sulphide of lead, carbonate of lead, cork.

Saponified resin, wheat flour, middlings, petroleum, animal fat, soda.

Type-metal and caoutchouc.

Anthracite coal and tallow.

Oxide tin, beeswax.

Soapstone, magnesia, lime, oil.

Sulphur, petroleum.

Vulcanized rubber, petroleum, tallow.

Paraffine, oil, milk of lime.

Asbestus, tallow.

Spermaceti, india-rubber.

Tallow, petroleum, soda, hair.

Mercury, bismuth, tin, antimony.

Crude petroleum, sal-soda, lime, tallow, lard, salt, pine-tar, spirits turpentine, camphor, alcohol.

Sulphur, plumbago, mica, tallow, oil.

Palm-oil, paraffine, tallow, alkali, asbestus.

Tallow, oil, paraffine, lime-water.

Flaxseed-oil, cotton-seed oil, lime-water, tallow.

Petroleum, tallow, beeswax, soda, glauber's salts.

Animal-oil, croton-oil, spermaceti, tallow, soda, potash, glycerine, ammonia.

Mica.

Sheets of paper or of fabric, impregnated with graphite, steatite, paraffine, tallow, size, or soluble gums, are used for lubricating.

The best lubricant for bullets was found by the Springfield Board to consist of eight parts bayberry-wax and one part graphite. Japan wax is often used with graphite, but with inferior results.

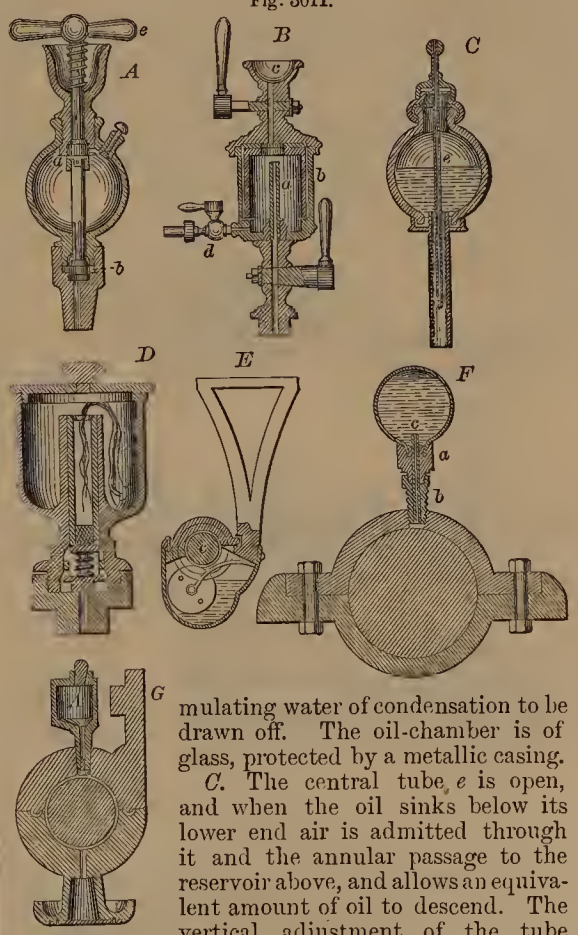
Graphite cannot be made fine enough for lubricating purposes if separated by bolting, but must be separated by floating either in water or air. The simplest method is the water separation, and during the process it should be treated to a bath of dilute sulphuric acid, which will take up the particles of spar and iron, leaving the sulphates of lime, magnesia, and iron easily washed out. The mode of floating and settling to obtain the powder of ultimate fineness is described under PENCIL. For the finest pencils, for lubricating and for electrotyping, the mineral should be in impalpable condition.

Lu'bri-ca-tor. 1. (*Steam-engine.*) An oil-cup or other contrivance for supplying oil or grease to rubbing surfaces, in order to diminish friction. The number of patented devices of this kind is large. A few are shown in Fig. 3011.

In *A* the two valves *a b* are connected by a rod. By turning the handle *e* in one direction the valve *a* is depressed by means of a pin working on an inclined plane, and admits oil to the reservoir. A reverse motion opens the valve *b*, furnished with a similar contrivance, permitting the oil to flow from the reservoir. The valve *a* is kept to its seat by a spiral spring on the rod.

B. Steam is admitted through the pipe *a* to the oil-chamber *b*, forcing out the lubricating material through an opening to the desired point. The supply of oil from the cup *c* is regulated by a cock, and a cock *d* at the side of the oil-chamber permits accumulating water of condensation to be drawn off. The oil-chamber is of glass, protected by a metallic casing.

Fig. 3011.



Lubricators for Machinery.

C. The central tube *e* is open, and when the oil sinks below its lower end air is admitted through it and the annular passage to the reservoir above, and allows an equivalent amount of oil to descend. The vertical adjustment of the tube regulates the flow by determining

the hight of the column of oil resting upon the journal.

D. The oil is conducted from the annular reservoir by a wick of fibrous material into the tubular valve-stem. This stem has radial holes at its lower end for the discharge of oil, and wire-gauze to arrest impurities. Between the upper and lower valves is a spiral spring. When the engine is running, the valves are closed by steam and spring pressure; when stopped, the upper valve is closed by the spring, and when running without steam both valves are sucked open and the oil flows.

E. 2. (*Shafting.*) A pivoted disk in a cup below the lower journal-box is revolved by contact with the under side of the shaft *c*, and carries up oil to lubricate the latter. See also SHAFTING; JOURNAL-BEARING.

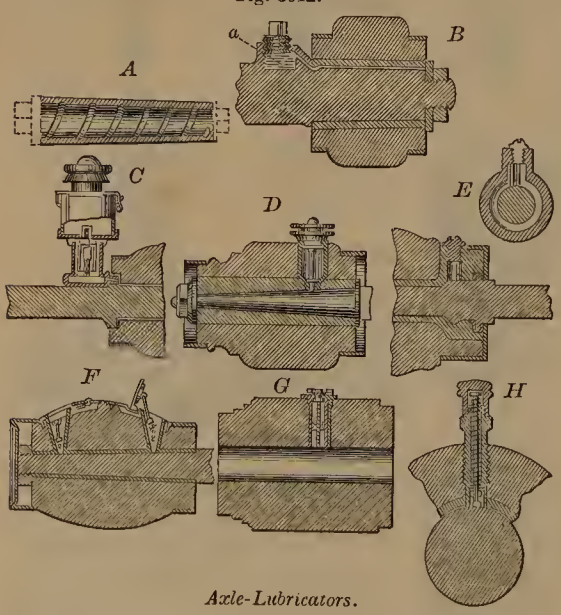
F has a transparent reservoir with metallic socket *a* screwing into the seat *b*, fitted to the cap of the journal-box. Between this and the journal is a slight vacuity, from which air is admitted through the tube *c*, allowing a greater or less quantity of oil to flow in proportion as the journal turns more or less rapidly. When at rest the flow ceases.

G. The flow of oil from the cup *A* is regulated by an adjustable screw-plug. The bearing has ducts for conveying surplus oil from the upper part of the shaft toward the center, and at its lower part is a closed chamber forming a drip-cup.

3. (*Vehicle.*) The ordinary mode of lubricating carriage or wagon axles is by placing grease on the spindle and then putting on the wheel, giving it a few revolutions before lowering it again to the ground. The grooves in the box of the hub form pockets in which the grease collects, and from which it passes to the spindle as it gradually wastes away. Many patents have been granted for devices in the boxes for retaining the lubricant, and are cited under AXLE-BOX.

In Diller's (*A*, Fig. 3012), a spiral groove is formed around the inner surface of the box, and leads the grease to all parts of the spindle, while the integrity of the bearing-surface of the box is not materially interfered with.

Fig. 3012.



Axle-Lubricators.

The lubricating devices are attached to the spindle or axle, or to the hub of the wheel. Of the former, two will be cited as representatives of their section of this class.

Those attached to the hub are the more numerous.

B. The reservoir *a* is closed by a screw-plug, which is turned to force the oil through a duct leading to a groove in the upper part of the spindle. The groove tapers toward the outer end, so as to distribute the oil equally.

C. A *lantern* is attached to the axle of the carriage just inside of the butting-ring. The oil-reservoir, besides furnishing supply to the wick of the lantern, also supplies oil through a duct to the bearing surfaces.

D. A tube passes radially through the hub, its lower end opening into the interior space of the box. The oil-reservoir is covered by a screw-cap. The inner end of the tube is closed by a valve whose stem is attached to the cap. By turning the screw-cap the valve is opened or closed, and the oil allowed to flow, or is cut off.

E. An oil-chamber is made in the box and communicates with the bearing surfaces. The reservoir is closed by a screw-plug, and the oil passes gradually to the spindle without special attention.

F. One or more conical openings in the hub, each closed by a spring-lid to which a rod and sponge are attached, extend to the axle. The sponge is charged with oil on opening the lid. This is kept shut by the spring when the wheel is in motion.

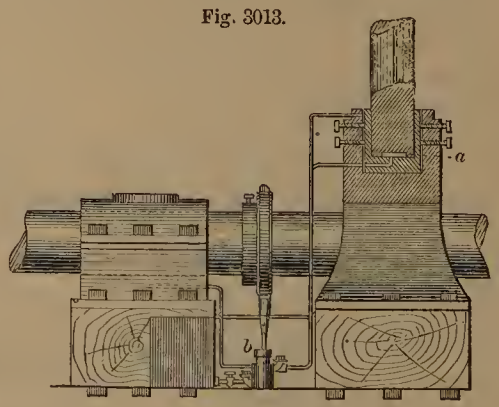
G. An oil-cylinder, having a piston on a screw-rod which works through the cylinder-cap, is inserted in the hub. Turning the head of the rod pushes the piston down, forcing the lubricant upon the axle-spindle. The piston is kept from rotating with the screw-cap by a groove in its edge, into which a feather on the inside of the chamber fits.

H. The depression of the spring-valve allows oil to flow from the chamber to the spindle of the axle.

The patents on lubricators are very numerous. Those referring to *railroad-axles* and *journal-bearings of machinery* are treated separately. Oil cups and cans, which are portable lubricators, are treated of under their proper title, OIL CUPS AND CANS.

The *hydrostatic lubricator* for heavy bearings consists of a chamber *a*, into which oil is forced by a hydrostatic pump *b*. By this means, at every revolution, the shaft is raised from its seat by the pressure of the oil. On the return stroke of the pump, the shaft seats itself on the oil that has been forced under it; the oil returns back to the pump as it flows through the bearing. Unlike other systems of hydrostatic lubrication, this does not seek to keep the shaft in equilibrium; but, on the contrary, it keeps it in constant motion up and down, by the

Fig. 3013.



Hydrostatic Lubricator.

injection of the oil, aiming thus to secure a more perfect lubrication.

It is stated that a step in Starr's Flour-Mill, at Vallejo, California, supporting a four-ton shaft making ninety-three revolutions per minute, has been run constantly, day and night, for seven months, with this lubricator, without changing the oil; and the oil, when taken from the reservoir at the end of that time, had not become thickened or discolored in any appreciable degree. See PALIER GLISSANT.

4. (*Ordnance.*) An arrangement for lubricating and cleaning the grooves of rifled guns.

In the English service it consists of a copper wad containing equal parts of tallow and oil, then a felt wad, and then a disk of millboard, all joined together. The copper is placed against the projectile, and when the charge is exploded the oil is ejected and lubricates the bore, while the felt wipes out the piece.

Lu-cer'nal Mi'cro-scope. A microscope in which the object to be examined is illuminated by the light of a lamp.

The object is placed in a sliding tube between the lens and the lamp, which is contained in a box. The image is received on a screen or plate of ground glass.

Lu'ci-fer. Originally, a match tipped with a mixture of chlorate of potash and sulphuret of antimony, which were inflamed by friction upon a piece of emery-paper.

These were superseded by mixtures containing phosphorus. See LIGHTING-DEVICES.

Lu-cim'e-ter. An instrument for measuring the intensity of light. A photometer.

Various photometers have been invented by Huyghens, Rumford, Celsius, Bouguer, Priestley, Ritchie, Arago, and others, which are described under that head. See PHOTOMETER.

Celsius called his device a *lucimeter*, and the name has since been adopted by Deslaurier in his modification of Bouguer's apparatus.

Deslaurier's apparatus is designed for measuring the quality of burning oils by their illuminating power. It consists of two constant-pressure lamps, and its shape is triangular; sheet-iron screen, painted black, and divided into two equal compartments. The latter are turned toward the lamps, while the observer stands on the opposite side, which presents nothing but a flat vertical surface, pierced with a hole bisected by the partition. Each of the two lamps is so placed as to transmit its light to only one compartment, and exactly to the part where the hole is. The hole is covered with a piece of transparent paper, on which the light from the two lamps is contiguously depicted. If their intensity is the same, the observer will perceive no difference. If not the same, one lamp must be moved back until its light is equal to the other in intensity, and the difference in the distance of the two lamps will make the relative quality of the two oils, which, combined with the quantity consumed in a given time, will determine their marketable value. The ratio of value is directly as the squares of the distances.

Luff. (*Nautical.*) The foremost or weather edge or leech of a sail.

To *luff* is to bring the ship's head nearer to the wind.

A *luff-tackle* has a *double* and *single block* and a *fall*, and is used for many purposes.

Luf'fer-board'ing. Slanting slats placed one above another, with intervals, so as to shed the rain, but permit ventilation; or the exit of sound from a belfry, or smoke and steam from a boiling-house.

Luff-tack'le. (*Nautical.*) A purchase composed of a double and a single block. The standing end of the rope is fast to the single block and the *fall* comes from the double.

Luff upon Luff. (*Nautical.*) One luff-tackle applied to the *fall* of another.

Lug. A projecting stud or ear by which an object is grasped or supported, or which affords a bearing or point of attachment; as, —

The lugs on the *parts* of a flask by which they are united. The lugs by which a kettle is supported in a furnace, etc.

Lug'gage-sad'dle. (*Mcnage.*) A pad on a led horse for carrying baggage.

Lug'gage-van. 1. (*Railway.*) The English term for a baggage-car.

2. (*Vehicle.*) A *fourgon*, or van containing personal baggage, attending on a traveling-carriage.

Lug'ger. (*Vessel.*) A small vessel carrying two or three masts and a lug-sail on each.

Lug-sail. (*Nautical.*) A four-cornered sail bent to a yard, which is slung at a point $\frac{2}{3}$ of its length from the peak.

A vessel thus rigged is a *lugger*.

Lum'ber. Timber sawed into merchantable forms.

Lum'ber-dry'er. A shed or closed chamber in which sawed lumber is subjected to an artificially heated and dried atmosphere. In the example, a series of girts having a ribbed edge on the inside, for the purpose of supporting strips, are arranged

Fig. 3014.

Lumber-Dryer.

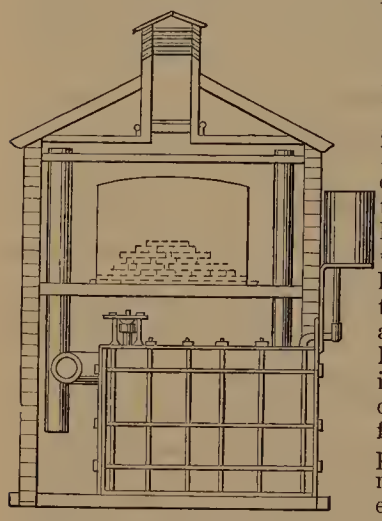
within a suitable building, the strips serving to hold boards or lumber on end. The drying-sheds have grated or open floors for sticking lumber standing on end, and are built double with a space between for an elevated railway track and car, the latter having a swivel platform.

In Fig. 3015, a continuous supply of water is introduced by gravity into the generator. The dry

steam is introduced within the kiln, and, after absorbing the moisture of the lumber, is conducted to the escape.

In another apparatus for this purpose, the process consists in subjecting the lumber to the action of a gradually increasing temperature, in an air-tight chamber, until all or nearly all the moisture has been extracted from it; in retaining all the heat and watery vapor about the lumber until a temperature of about 170° Fah. has been attained in said air-tight chamber; and, finally, in compelling the heated moistened air to escape slowly from said chamber while the temperature is reduced therein.

Fig. 3015.



Lumber-Dryer.

Davis and Symington's lumber-dryer, English patent, 1843, acts by means of a heated blast upon lumber or wooden articles placed in a chamber through which the blast is driven. By their process, —

Mahogany is reduced in weight	24.4 per cent.
Pine is reduced in weight .	34.5 per cent.
Fir is reduced in weight . .	12.5 per cent.

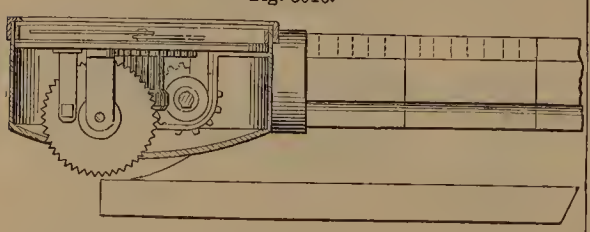
Lum'ber-kiln. A heated chamber for artificially drying lumber. See LUMBER-DRYER.

Plank should never be allowed to remain undisturbed until it seasons; but should all be handled over and repiled from time to time, removing the sticks from their former positions. The planks should be turned over, especially if they have become bilged.

Two to six years are required to season timber, according to its size. It can be seasoned more quickly if it be steamed, but excess in steaming kills the elasticity of the timber. Too rapid kiln-drying evaporates the surface moisture too rapidly, and causes the timber to check.

Lum'ber-meas'ure. One by which the number of superficial feet contained in boards of different lengths can be estimated. Within the case is a disk in a vertical position, which, by being made to pass over the surface of the boards, indicates on a dial their superficial contents. Connected to the shaft

Fig. 3016.



Lumber-Measurer.

of the disk is a sliding shaft, carrying on its end an endless screw, through which the motion of the shaft of the measuring-disk is transmitted to the arbor, carrying the index-heads in such a manner that by simply adjusting the sliding shaft the instrument can be set for boards of different lengths. A sleeve projecting from the bottom of this case and terminating under the center of the disk enables the operator to commence measuring with the edge of the board directly under the center of the disk.

Lum'ber-wag'on. A heavy wagon, long coupled, and having standards to the bolsters, for hauling sawed timber.

Lump. 1. A bloom or loop of malleable iron.

2. The nipple-seat on a gun-barrel.

Lu-nette'. A term applied to objects of a half-moon shape.

1. (*Fortification.*) A detached work presenting a salient angle towards the enemy, and having flanks open at the *gorge.*

With the flanks it has the character of a *detached bastion;* without the *flanks,* it would be a *redan;* with the *gorge* closed, it would become a *redoubt.*

2. (*Ordnance.*) A forked iron plate into which the stock of a field-gun carriage is inserted.

3. (*Architecture.*) *a.* An arched aperture in the side of a long vault, and having a less hight than the pitch.

b. A semicircular aperture in a concave ceiling.

c. An opening in the roof of a house.

4. (*Farriery.*) A horseshoe having only the front, curved portion; lacking the branches.

5. The flue connecting the fire-chamber with the pot-chamber of a glass-furnace.

6. (*Harness.*) A blinder for the eyes of an intractable horse.

7. (*Optics.*) *a.* A perifocal spectacle-glass; concavo-convex, its curve approximating the shape of the eye and affording more distinct oblique vision.

b. A flattened watch-crystal or glass, to avoid adding to the thickness of the watch.

The edge of the watch-glass fits within the bezel.

Lurch-line. The line which draws the bird-net over the prey.

Lure. A velvet brush or smoothing-pad used by hat-makers. From *Velure* (Shaks.), velvet. Fr. *Velours;* Old Fr. *Villuse;* from Lat. *Villosus,* hairy. Also called *velour; lewer.*

Lus'ter. 1. (*Fabric.*) A lady's dress-goods with a cotton chain, woolen filling, plain or *self* color, and highly finished surface.

2. A sconce or chandelier.

Lus'ter-ing. 1. A polish; as black-luster for stoves, etc.

2. (*Metallurgy.*) The brightening of metal in the crucible at the moment of reaching its point of purity. As in the cupellation of silver, when the last traces of lead pass off. *Brightening; lightening.*

Lus'ter-ware. A stone-ware on whose surface are burnt metallic oxides of brilliant colors. It is made of a mixture of clay, flint, China-stone, and felspar, coated with a peculiar glaze on which is applied, by means of camel-hair brushes, a pigment prepared from metallic oxides, simulating the luster of various metals, etc. Platinum produces a luster like that of polished steel; gold and silver, those of the precious metals. Iron and copper lusters may also be produced. A beautifully iridescent appearance is derived from chloride of silver in combination with other substances.

The luster is brought out by the heat of the oven in the process of baking.

Lus'tring. (*Fabric.*) A shining silk; *lute-string* is a corruption.

Lute. 1. To stop with clay; as the cover of a furnace, or a muffle to resist the passage of fumes, or of a charged retort to prevent the escape of gas around the cover.

2. A composition to secure the joints of chemical vessels and tubes, or as a covering to protect them from the fire.

Their compositions are various; e. g. —

1. Linseed-meal and whiting.
2. Lime and bullock's blood.
3. Plaster of paris.
4. Powdered clay and boiled oil.
5. Powdered clay, ground brick, and borax water.
6. Pipe-clay and horse-dung.
7. Vulcanized rubber thimbles.

A lute for the bungs of powder-cases is formed of tallow, 14; beeswax, 6. Melted together and softened by beating before using.

Lutes not exposed to high temperature may be made of *moistened bladder*, *linseed-meal*, and *gum-water*, *white of egg* and *quicklime*, *glazier's putty* (chalk and linseed-oil), *pipe-clay* and *drying-oil*.

Lutes for high temperatures are made of clay and sand, beaten into a paste and thinned with water. If intended to vitrify, borax or red-lead may be added.

Fat lute is made of finely pulverized pipe-clay and drying linseed-oil. It is used to join parts of apparatus exposed to considerable temperature, and intended to contain corrosive vapors. It is tied on by strips of bladder.

Iron cement is formed of sulphur, 1; sal-ammonia, 2; iron turnings, 80. Calked into the joints.

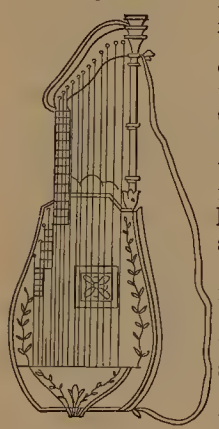
3. A packing-ring of india-rubber placed between the lid and the lip of a jar, to prevent the access of air to the contents. See FRUIT-JAR.

4. (*Music.*) A musical stringed instrument, played like a guitar, but having a pear-shaped form and a ribbed back. It is derived from the lyre.

The old Egyptian lute is represented in many places in Egypt; one at Thebes has a long neck without frets, three strings, and a fiddle-shaped body.

A lute shown on the signet-ring of Shoofoo, the Suphis of the Greeks (2325 B. C.), has a fretted neck. See the late Dr. Abbott's collection, New York. In Egypt we find the originals of most of the types of musical instruments. See HARP; CASTANET; DRUM, etc.

Fig. 3017.



Ventura's Lute.

The lute consists of four parts: the *table;* the *body*, which has nine or ten sides; the neck, which has as many stops or divisions; and the head or cross, in which the screws for tuning it are inserted. The performer strikes the string with the fingers of the right hand, and regulates the sounds with those of the left.

Simply constructed, it is called the *French* lute.

With two necks, — one for the base notes, — it is called a *theorbo*. If the strings of the *theorbo* are doubled, it is called an *arch-lute*.

Ventura's lute is intended to combine the principles of the *harp*, *lute*, and *guitar*. The performer is enabled to stop the treble strings on a finger-board, which materially increases its compass, and yet retains the fullness of tone of the other strings.

5. A straight-edge employed to strike off the surplus clay from a brick-mold.

Lute'string. (*Fabric.*) A plain, stout silk or silk ribbon: from *lustring*.

Lu'thern. An upright window in the roof. A *dormer*-window.

Lych'no-scope. (*Masonry.*) A narrow window near the ground.

Lye. A solution of an alkali. Used in soap-making; in neutralizing an acid; in cleansing grease from objects, such as thin iron plates in the operation of tinning, etc.

Lyre. A stringed instrument of the harp kind. Its origin is lost in antiquity. It is claimed of course by the Hellenic Greeks, who learned so much from the nations of Egypt, Phœnicia, and Asia Minor, and then slurred the debt in a muddle of mythology. This latter indeed was similarly derived and fearfully garbled. It cannot even be admitted that the Egyptian lyre was but of 3 strings, the other 4 being added by the Greeks to form the *heptachord*. The origin of the lyre is attributed by the Greeks to Hermes. (See HARP.) It was specially the musical instrument of Apollo.

The ancient Egyptian lyre was made in various forms, some of them very ornate. It was sometimes

Fig. 3018.

Egyptian Lyres.

struck with the *plectrum*, and sometimes the strings were played by hand. The strings were of catgut, and numbered from four to eleven in the different figures.

The lyre is represented in the sculptures of Nimroud.

Some of the early Grecian lyres had an arrangement for changing the length of the string. This was done by a sliding bar, which might be moved by the musician during his performance.

The same idea has been introduced in modern lyres or harp-lutes, in which eight strings have, by this means, been made to yield twenty-four distinct tones.

The lyre was, in fact, a small harp, and the hollow resonant portion became, in time, expanded into a chamber over which the strings were stretched in parallelism, forming a *dulcimer*, the immediate parent of the *hammer* group, — *citole*, *clavichord*, *claviecytherium*, *virginal*, *spinet*, *harpsichord*, *piano* (see PIANO). Another, and perhaps earlier, divergence of the instrument with strings in parallelism above a sounding-board is found in a portallo class, — the *monochord*, *cithara*, *guitar*, and a host of other instruments with names less widely known, such as *theorbo*, *pandore*, *mandolin*, etc. These instruments were played by the *fingers* or by a *plectrum*, and from them came out the class of instruments played by the *bow*, of which the *viol* is the head, and the others take their names as relatives, — *violin*, *viola d'amour*, *violoncello*, *bass-viol*. See "Description des Instrumens Harmoniques," by Father Bonanni, Rome, 1776.

M.

Mac-ad'am-iz-ing. A mode of paving roads, introduced by Macadam, the *metal* or surface stone consisting of pieces of granite, whinstone, limestone, or hard freestone, according to the kind of rock which is accessible.

Telford's rule, when two courses were used, was to make the lower one of blocks 7 inches in depth, laid by hand, broad end downward, and chinked with smaller stone.

Over this, 7 inches of smaller stones were laid, no stone to weigh over 6 ounces, and all to pass through a metallic ring 2½ inches in diameter. The stone is broken to uniform sizes, and several machines have been devised for this purpose. See STONE-CRUSHER.

Ellis and Everard's stone-crushing mill has a strong feed-apron, composed of iron links and bars, which, passing around two wheels, delivers fragments of granite to a hopper which feeds them between two chilled-iron crushing-rollers; they then pass between a second pair of rollers which still farther reduce them in size. The rollers are fluted, and may be adjusted to break the stone to any required size. From the rollers they pass to a revolving griddle, which separates those of the proper size. Those which are too large are raised by an elevator to be again passed through the machine. Rolls weighing 10 cwt. each will, it is said, crush 1,800 tons of granite before being worn out; and it is claimed that the work is performed in England at one fifth the cost of doing the same by hand.

The stone-grinding mill of Neal is designed for *pulverizing* stone. See also ORE-MILL.

Mace. 1. (*Weapon.*) A mallet, hammer, or slung-shot used in the Middle Ages to oppose warriors in armor. It had many forms: a simple iron club; a spiked club; a pointed hammer; an iron-spiked ball chained to a handle about 2 feet long. The latter were called *morning stars* by the train-bands of London; a grim pleasantry.

The Assyrian soldiers used "wooden clubs knotted with iron." — HERODOTUS, VII. 63.

The bent maces (*lissan*) are found in the old Egyptian pictures, and are yet common in Africa and elsewhere.

In the times of the Plantagenets the mace was used in battles and tournaments, and was superseded by the pistol in the time of Elizabeth. The mace is still retained among the Turkish cavalry.

2. (*Leather.*) A currier's mallet with a knobbed face, made by the insertion of pins with egg-shaped heads. It is used in leather-dressing to soften and supple the tanned hides, and enable them to absorb the oil, etc. It is analogous to the fulling-hammer.

Mac'er-ate. To wear away by steeping.

To saturate a substance, — fiber for paper, for instance, — so as to distend the fibers.

Mac'er-a'tion. The process of softening and separating the parts by steeping.

A *solution* is the diffusion of the particles of a solid in a liquid without change of its nature.

An *infusion* is a solution obtained by steeping at a moderate temperature.

A *decoction* is a solution obtained by boiling.

A *steep* is a solution obtained by maceration or soaking, as the ooze of bark; or by simply dissolving, as a mineral salt forming a mordant or a fertilizing liquid.

Ma-che'te. The Spanish implement for cutting cane, corn, vines, etc. It is now made in large quantities for the Southern market, and many of the implements are diverted to home use, as corn and cane knives. See CORN-KNIFE.

Mach'i-co-la'tion. (*Architecture and Engineering.*) Apertures between the corbels supporting a projecting parapet. They were much employed in castellated architecture, and were intended for the purpose of allowing missiles to be hurled down on assailants approaching near the walls.

Ma'chi-cou-lis'-gal'ler-y. (*Fortification.*) A projecting gallery with loopholes arranged to obtain a downward fire on an enemy.

Ma-chine'. An instrument of a lower grade than an *engine*, its motor being distinct from the operating part, whereas the *engine* is automatic as to both.

It is also distinct from a *tool*, as it contains within itself its own guide for operation.

Ma-chine'-tool. A machine in which the tool is directed by guides and automatic appliances. Aptly called by Dr. Barnard "a mechanical artisan" with "iron arms." It is a workshop appliance for operating upon materials in the way of shaping and dressing, having devices for dogging the stuff and feeding the tool.

Among tools of this class for working in metal may be enumerated the lathe and machines for planing, slotting, shaping, drilling, punching, and shearing. See METAL-WORKING TOOLS AND MACHINES.

Machine-tools for wood are lathes, saws of various kinds, machines for planing, molding, boring, mortising, dovetailing, rabbeting, tenoning, shaping, etc. For these we are originally indebted to Sir Samuel Bentham and Brunel. See WOOD-WORKING TOOLS.

Ma-chin'ist's Ham'mer. A hammer which has a flat, round face and an edge-peen transversely of the helve. In some branches of the business it has two faces; in others, again, it has one face and a pointed peen for riveting.

Mack'le. (*Printing.*) A blurred impression, causing part of a page to appear double.

Ma-crom'e-ter. An instrument for measuring inaccessible objects by means of two reflectors on a common sextant. — WEBSTER.

Ma'cron. An accent (-) placed over vowels to give the long sound.

Mad-a-pol'lam. (*Fabric.*) A kind of fine, long cloth (cotton) shipped to the East India market.

Mad'der-style. (*Calico-printing.*) A method of calico-printing in which the mordants are applied to the white cloth, and the colors are brought up in the dye-bath. See CALICO-PRINTING.

Made-mast. (*Nautical.*) One composed of several pieces. A *built*-mast.

Mad-is-te'ri-um. (*Surgical.*) A tweezers. An instrument for extracting hairs.

Ma-drier'. *a.* A thick, iron-plated plank, having a cavity to receive the mouth of a *petard*, which is applied to a gate or other obstacle to be blown down.

b. A beam laid in a ditch to support a wall; or in a mine or bomb-proof to support a side or roof.

Mag'a-zine'. 1. (*Fortification.*) A building, vault, or apartment designed for the storage of ammunition, gunpowder, and other explosive substances.

Magazines in field fortifications are constructed in the most sheltered parts of the work, partly underground where practicable, and are lined with timber or with gabions, the ceiling being of timber. The

whole is covered with a sufficient thickness of earth to render the structure bomb-proof.

Permanent magazines are usually constructed of brick, and should be surrounded by an earthen mound, so that in case of explosion the tendency of the explosive force may be upward.

As little iron as possible should be employed in the construction, and all iron nails, etc. should be sunk below the surface of the wood and their heads puttied over. The windows have exterior metallic shutters and interior shutters of wire-gauze; ventilators, closed by sliding metallic shutters, are also generally arranged around the lower part of the sides of the building. Powder is stored in barrels, three or four tiers high, with skids between each tier, or sometimes racks are arranged to receive the barrels. Alleys of sufficient width are left between the several piles to obtain ready access to each barrel. Fixed ammunition and small-arm cartridges are piled in a similar way, but these, when practicable, should not be placed in the same magazine with gunpowder.

2. (*Nautical.*) On shipboard the magazine is an apartment placed sufficiently below the water-line to be safe, under ordinary contingencies, from the enemy's shot. It is lined with sheet-copper, and has tiers of shelves on three sides and in the middle for the reception of the copper canisters, in which the cartridges for the heavy guns are contained. It is illuminated by a peculiarly constructed lamp and reflector placed at one end of and just outside the magazine, and carefully isolated therefrom. In action, the cartridges, when taken from the ammunition-boxes, are passed through a scuttle by a man in the magazine to another on the deck above, who in turn delivers them through a canvas screen having an opening covered by a flap, to another on the other side, who hands them to the runner-boys, who pass them through scuttles to others on the deck or decks above, until they reach the powder-boys, who deliver them to the loaders stationed at the guns.

Large vessels have two magazines, one forward and the other aft.

3. (*Stove.*) A chamber in a stove or furnace containing a supply of fuel which falls or is fed into the combustion-chamber as the fire burns away that previously introduced.

The first magazine-chamber for fuel known to the writer is the Athanor of the alchemists of the Middle Ages. This was the original *base-burning* furnace, and was adopted to keep up a continuous supply to the fire, which it was hoped would eventually transmute the baser metals into gold. See ATHANOR.

Delasme's furnace, 1685, is not exactly a magazine, but is a downward-draft furnace. See SMOKE-CONSUMING FURNACE.

Watt's base-burner furnace had a magazine (English patent of 1785). The fire is fed from a reservoir above, and the resulting volatile products pass through the fire to the chimney.

Cutler's magazine-grate was patented in England in 1815. The bottom plate of the chamber was movable, and by means of a wheel and axle the fuel contained in the chamber was raised so as to bring a new portion of fuel into the fire. The object is a full supply for a day, and a means of introducing below so as to burn the smoke.

Arnott's improvement, which he termed a smokeless fireplace, is somewhat similar.

Deakin's patent, 1816, had the magazine at the back of the fire, and the fuel was drawn forward horizontally by means of a screw.

Alkin's English patent, 1825, resembled Deakin's.

Rawe's magazine, 1854, is a fuel-pipe connecting the bottom of the grate with a side reservoir of fuel. The poker is the lever for introducing a fresh supply.

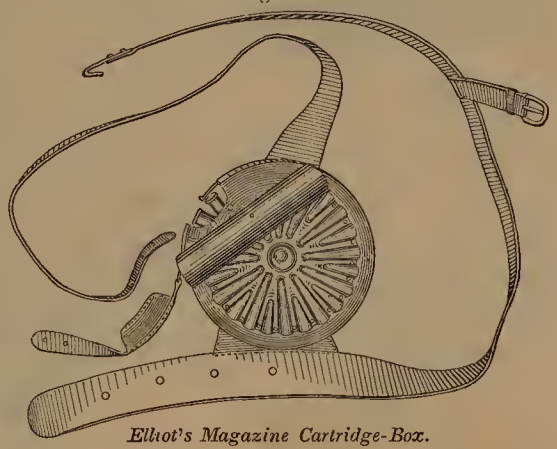
Leighton, in 1856, surrounded the sides and back of the chamber with a fuel-reservoir, from which the fuel was withdrawn by the poker. See MAGAZINE-STOVE.

4. (*Fire-arm.*) A chamber in a gun containing a succession of cartridges, which are fed one by one automatically, and loaded at the breech of the gun. See MAGAZINE FIRE-ARM.

Mag'a-zine' Car'tridge-box. A cartridge receiver attached to a gun, or to the person near the gun, to facilitate loading.

"Elliot's cartridge-box consists of two metallic plates mounted side by side on a common pivot, by which they are secured to a skeleton metallic frame covered with leather. They are fluted radially for the reception of 24 cartridges. These flutings are so arranged that the heads of the cartridges may lie in an almost continuous row, while the points overlap each other in such a manner that the cartridges

Fig. 3019



Elliot's Magazine Cartridge-Box.

are mutually supported by the ends of their cases, the weight being thus taken off the point of the ball, and removing its liability to be driven into the cartridge by the shaking of transportation.

"The box when used is to be worn on the left breast. When charged it is rotated for firing by bringing each cartridge in succession to an open notch in the periphery of the frame." — *U. S. Ordnance Memoranda*, No. 15, p. 339.

Merrill's box is a slot in the top, back of the *small* of the stock, from which the cartridges are taken by hand and fed to the chamber.

Hagner's magazine is a box large enough for three cartridges, open at one end, and situated under the barrel, forward of the trigger-guard.

Benton's, Hare's, and Metcalfe's magazine-boxes are detachable blocks containing each a number of cartridges. The blocks fit in the cartridge-box, and when in use are attached to the side of a rifle, near the breech-block, by dovetail or pin fastening.

Mag'a-zine' Fire-arm. One containing a supply of cartridges, which are automatically fed to the chamber at the rear end of the barrel. There are several types.

1. Those in which the magazine is a tube below the barrel, as in the Winchester, the Ward-Burton, etc.

2. Those in which the magazine is in the stock, as in the Spencer, Meigs, and others.

3. Those in which the magazine is a separate piece attachable to the gun when required, as in the Elliot carbine, the Gatling battery-gun, etc. See BATTERY-GUN.

The Marquis of Worcester (d. 1667), in his "Cen-

tury of Inventions," refers to an "often-discharging pistol," but does not describe it. In 1575, several of such arms were stored in the Tower of London. Porta, in his "Natural Magick," 1658, speaks of a great brass gun, or hand-gun, which may discharge ten or more bullets without intermission. The idea is to load with powder and shot alternately, until the barrel is full; an intervening "dark powder" gives an interval between the firing of the separate charges, so as to avoid the simultaneous explosion and the results which would very certainly follow.

Most of the ancient repeating-guns were many-chambered revolvers, and not what we term magazine-guns. See REVOLVER.

The Henry or "Winchester" rifle will fire sixteen shots without reloading, and the gun is cocked by the same movement of the guard that opens and closes the breech; the exploded cartridge being withdrawn and a fresh one supplied at the same time and by the same movements. The copper cartridges, fifteen in number, are placed in a tube extending the entire length of the barrel on its under side, from which they are fed into the gun by the operation of the lever-guard, a spiral spring forcing back the cartridges as fast as they are used up. The piece has been fired fifteen times in less than ten seconds. 187 shots were fired in 3 minutes and 36 seconds, not including the time required to replenish the magazine; and, including the time thus employed, 120 loads were loaded and fired in $5\frac{3}{4}$ minutes, — 1,040 shots being fired without cleaning or repairing the gun. See *Y Y'*, Plate XVIII., FIRE-ARM.

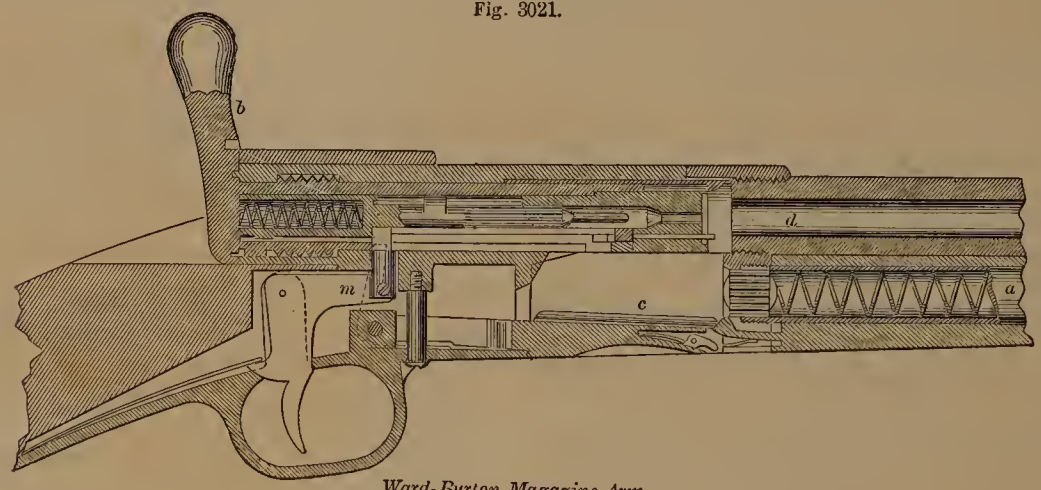
Fig. 3020.

Winchester Magazine Fire-Arm.

Fig. 3020 shows a longitudinal section of the breech and working parts of the magazine, with a cartridge on the carrier ready to be fed to the firing-chamber.

The Ward-Burton arm is on the bolt system. A supply of cartridges is carried in a tube *a* beneath the barrel. These are fed backward by a spiral spring. The gun is opened by raising the handle *b* of the bolt and withdrawing it. As the bolt is fully drawn back, it strikes the upright arm of the carrier, shown by dotted lines (at *m*), on the tray *c* formed by the lower arm of which a cartridge has been fed by the action of the spiral spring in the magazine-tube. The motion of the bolt brings up this tray, so that, when pushing forward the bolt again to close the piece, the cartridge may be driven into the chamber *d*, where it is fired by the action on a heavy needle or pin of a spiral spring contained in the bolt and compressed in the act of closing, during which, also, the carrier is forced down to receive a fresh cartridge from the magazine.

Fig. 3021.



Ward-Burton Magazine-Arm.

Projecting from the face of the bolt is seen the point of a spring hook, serving to withdraw the empty shells from the chamber, and also the end of the ejector-pin, which strikes them from below when withdrawn, and throws them clear of the gun. Near the head of the bolt is seen part of the sectional screw, which engages with a corresponding section within the gun when the piece is closed, and the handle turned down into place, and so supports the bolt against the force of the discharge. The magazine holds eight shots, which may be fired in about nine seconds; their issue may be cut off by a sliding piece; the arm may then be used as a single loader, (as shown in Plate XVII., opposite page 852), holding the magazine in reserve.

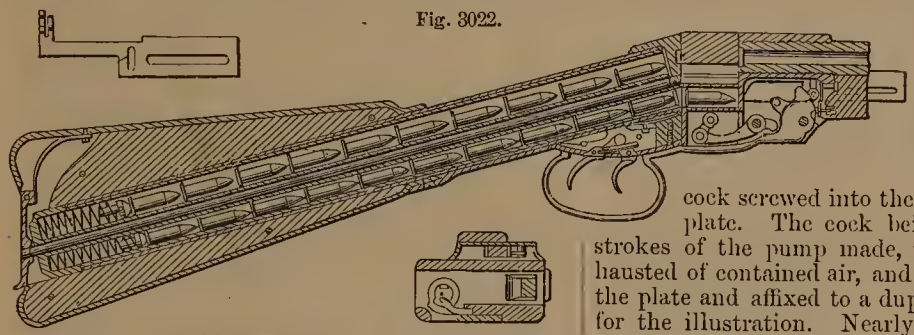
The Swiss magazine-rifle (shown on Plate XVIII., opposite page 853) has the bolt feature of the Ward-Burton, and the cartridge-loader of the Henry, so well known as the "Winchester."

The Spencer has a tube containing seven copper cartridges placed lengthwise in the stock, from whence they are forced, one at a time, into the barrel, by merely moving the lever-guard forward and back, — the shell of the exploded cartridge being removed by the same operation. The gun is then cocked and fired in the usual manner. This gun was more extensively introduced into the army, during the late civil war, than any other of its class,

and is, therefore, very generally known. It is shown at *F*, Plate XVI.

The Cullen magazine-gun (Fig. 3022) has a revolving cartridge-carrier in the stock, which contains four sets of cartridges, ten in each set or column. As one column is exhausted another comes in place, so that forty shots may be fired without reloading.

Fig. 3022.



Magazine-Rifle.

The operating mechanism is connected to the trigger-guard, which works as in the Spencer.

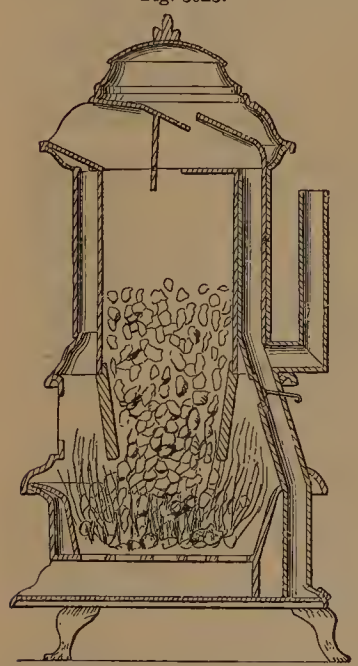
The Meigs magazine-gun, made at Lowell, Mass., contains five columns of ten each, or fifty cartridges, which were fired before the Austrian Military Committee in 16 seconds, and replaced by another magazine in a few seconds. The breech-block rises and falls by a backward and forward sliding reciprocation of the trigger-guard. When one line of cartridges is expended, the magazine is rotated on its axis by a spring bringing another line of cartridges in line with the feeding arrangement.

A number of magazine-guns carry cartridges in the stock, linked together like sausages, which are cut apart as they are used. See classification list under FIRE-ARM, pp. 854 – 862.

Mag'a-zine'-stove. One in which is a fuel-chamber which supplies coal to the fire as that in the grate burns away.

The example is a base-burning stove, having a fuel-magazine suspended free from the grate, and having an unobstructed free space around and below it, an illuminated casing surrounding it. See BASE-BURNING STOVE.

Fig. 3023.



Base-Burning Magazine-Stove.

Fig. 3024.

Magdeburg Hemispheres.

Mag'de-burg Hem'i-spheres. Hemispheres of brass whose edges are carefully ground together to make an air-tight joint, and designed to illustrate the pressure of the atmosphere. The experiment originated with the worthy Otto Güericke, burgomaster of Magdeburg, about 1654.

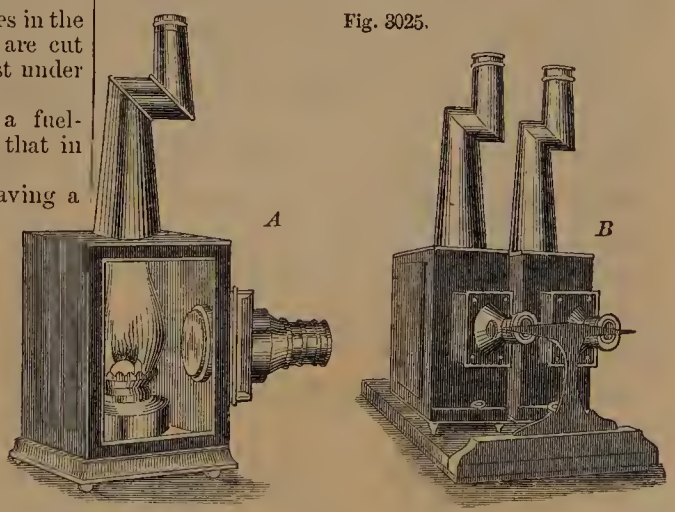
The edges of the hemispheres, being greased with oil or tallow, are brought together, the foot removed, and the stop-cock screwed into the center of the air-pump plate. The cock being opened and a few strokes of the pump made, the sphere is thus exhausted of contained air, and on being removed from the plate and affixed to a duplicate handle is ready for the illustration. Nearly fifteen pounds of force to the square inch will be required to draw them asunder. To separate them readily, it is only necessary to open the stop-cock and re-admit air.

Mag'ic Lan'tern. A dioptric instrument by which the images of small figures painted in transparent varnish are exhibited, considerably magnified, upon a wall or screen.

Its invention has been attributed to Roger Bacon about the year 1261, but it was first generally made known by Baptista Porta in his "Natural Magick," and by Kircher, 1669 – 70, who described it in his "Ars magna Lucis et Umbræ."

"Comes Mr. Reeves bringing me a lanthorn with pictures in glass to make strange things appear on a wall, very pretty." — PEPYS's *Diary*, 1666.

Fig. 3025.



Magic Lanterns.

As at present constructed, the instrument *A* consists of a case having a projecting tube in front, in which are two lenses, the inner for illumination and the outer for magnifying. A strong light is placed in the center of the box, and behind it a concave mirror. A widened space between the two lenses in the tube permits the insertion of the slips of glass on which the objects are painted. These are highly illuminated by the mirror and lens; and the magnifying-lens, which is adjustable to a proper focus by sliding it back and forth in the tube, throws a magnified image of the object on the screen placed to receive it. The magnitude of the image depends on the distance of the image from the screen, being greater the farther apart they are separated; this dis-

tance must not, however, be too great, or the image will be indistinct.

When the screen is transparent the exhibitor may be behind it, the picture being exhibited by transmitted light. With a white opaque screen, or a whitewashed wall, the camera is placed in a suitable position among the audience, and the picture, being thrown upon the screen, is viewed by reflected light.

The oxy-calcium light, in which a jet of oxygen gas passing through a spirit-flame is thrown on a cylinder of lime, or the electric light, are used in the magic-lantern, affording an illuminating power vastly greater than that of the ordinary oil lamp.

Fig. *A* represents a single lantern, and *B* a double lantern, the latter arranged for exhibiting dissolving-views. The lanterns are placed side by side, so that the sliders may be readily slid from one to the other. Their foci and the screen being properly adjusted, a picture is placed in each; in front of both tubes is a slider, by which the image of either is gradually shut off from the screen, so that one image will appear to dissolve into the other.

Mag'is-ter'y. A fine substance deposited by precipitation.

Mag'is-tral. 1. (*Metallurgy.*) Made from copper pyrites (or raw magistral), which is found in many parts of Mexico. These ores, according to Napier, contain from 7.47 to 13.75 per cent of copper. It is reduced to powder by dry stamping and grinding. It is used especially in the *patio* process of amalgamation. Some authorities state that the copper pyrites are *roasted* and ground, but this would seem to detract from their activity, which is due to the action of their sulphuric acid upon the salt, liberating muriatic acid. So say Sonneschmid and Phillips. See AMALGAMATOR, p. 76.

2. (*Fortification.*) The line where the scarp, if prolonged, would intersect the top of the coping or cordon. — MAHAN.

The guiding line which defines the first figure of the works of a fortification.

Mag-ne'si-an Lime'stone. A mineral which crystallizes in the rhombohedral system.

Mag-ne'si-um. Equivalent, 12; symbol, Mg.; specific gravity, 1.743. A malleable metal the color of silver.

As a silicate or carbonate, it enters into the composition of many rocks and soils; steatite, serpentine, talc, meerschaum, etc.

The oxide, sulphate (epsom-salts), and carbonate are used in medicine.

It is also used in lamps. See MAGNESIUM-LAMP.

Mag-ne'si-um-lamp. One in which burning magnesium is employed for purposes of illumination.

This metal, in a state of combustion, emits a light which is unendurable to the naked eye, but at the same time gives forth a cloud of its oxide which eventually fills the apartment in which it is burned.

Various attempts have been made to obviate this difficulty, and it is found that by alloying with zinc the quantity of light is undiminished while the fumes are more readily removed. An alloy with thallium has also been successfully tried.

As the flame possesses, though in a much inferior degree, the actinic power of the sun's rays, it may be employed in photography.

Broad thin strips, presenting a proportionately greater surface to the oxygen of the atmosphere than those of equal weight which are narrower and thicker, burn more steadily and surely, and are preferable for giving light.

A long strip of this kind is coiled about a drum and fed by clock-work into the flame of a small alcohol lamp. There may, of course, be various modifications of the mechanism employed.

In one form of magnesium-lamp the metal is employed in a pulverized state, and may be used either alone, mixed with sand, or with a material as nitrate of strontia, to give color to the flame. It is placed in a funnel-shaped reservoir, from the lower part of which proceeds a long, narrow tube, at the lower extremity of which is a small spirit-lamp. This serves to ignite and maintain the flame of the powdered magnesium, the flow of which is regulated by means of a small finger-tap, so as to increase or diminish the light as required. The spirit-lamp also prevents the end of the tube from being fouled or stopped up by the oxide, which would otherwise form within and around it.

Such lamps may be made of convenient size for portability.

The light emitted by a magnesium wire one thousandth of an inch in diameter is equal to that of seventy-four stearine candles of five to the pound; three feet of it are burned per minute, or a quarter of an ounce per hour, the cost of which, at the present price, would be about 60 cents. Seventy-four stearine candles would, however, in the same time consume 2 pounds of stearine, which would cost 50 cents; 40.4 cubic feet of coal-gas of twelve candles power would be required to produce the same effect, and would cost about 5 cents. The dearness of magnesium arises from the high price of sodium required in obtaining it. Magnesium gives off $\frac{1}{265}$ of the heat obtained by combustion of gas of equivalent lucid effect. Gas and candles vitiate the air by the production of watery vapor and carbonic acid: magnesium is free from this objection, but it has an inconvenience of its own; a large quantity of calcined magnesia is thrown off as a fine powder, as stated above.

Mag'net. The attractive power of the loadstone or magnet was early known, and is referred to by Homer, Aristotle, and Pliny.

Says Pliny: "The magnet-stone is found in Cantabria." We read that the architect Dinochares was employed by Ptolemy to roof a temple at Alexandria with "magnet-stone," by means of which an iron image of his sister Arsinoe might remain perpetually suspended. Both the architect and the king died before the completion of the work.

This was probably the original of the popular fable of the suspension of the coffin of Mahomet at Medina between two magnets.

The name is derived by the imaginative Greeks from one Magnes, a shepherd on Mt. Ida, whose iron crook being casually laid against a block of magnetic iron became attached thereto, and directed attention to the mysterious attraction.

Thales, B. C. 640, discoursed on amber and the magnet, and supposed them to be living because they had a moving force.

"From Eastern Asia has been handed down the knowledge of the directive force and declination of a freely suspended magnetic bar; from Phœnicia and Egypt the knowledge of chemical preparations (as glass, animal and vegetable coloring substances, and metallic oxides); and from India the general use of *position* in determining the greater or less value of a few numerical signs." — HUMBOLDT.

Ætius, A. D. 500, refers to the use of the magnet for the cure of disease. He says: "We are assured that those who are troubled with gout in their hands or their feet, or with convulsions, find a relief when they hold a magnet in their hand."

Several eminent physicians of the fifteenth century affirmed its virtues as a cure for toothache, and a little later we read of magnetic toothpicks for the same purpose.

The deviation of the compass was known before Columbus, but it was assumed to be uniform. The first voyage of the great discoverer was nearly brought to an abrupt conclusion by the discovery of this error. See MARINER'S COMPASS.

The *dip* of the magnet was discovered by Robert Norman, 1576. See MAGNETOMETER.

The magnet worn by Sir Isaac Newton in his ring weighed only 3 grains, yet was able to take up 746 grains, or nearly 250 times its own weight.

Artificial magnets were made by Dr. G. Knight in 1746.

A natural magnet is the loadstone, which possesses polarity like a magnetic needle.

A magnetized needle is a piece of steel or iron to which polarity has been imparted by contact with a loadstone, or by other means. A manuscript of A. D. 1206, in the Royal Library of Paris, states that a black stone, called *marinière*, was rubbed by sailors upon a needle, which was then placed on a straw set afloat in a basin of water, when the point would indicate the north. See MARINER'S COMPASS.

A nicely balanced piece of steel, suspended by its middle by a piece of untwisted silk, will, when magnetized, turn in one direction and rest there.

Its deviation from the true meridian is its *variation* or *declination;* its deviation from a horizontal position is its *dip* or *inclination*.

Polarity may be conferred upon a bar of steel by different means: —

1. A steel bar held in the natural direction of a needle, and struck several blows with a hammer, will become magnetized.

This occurs on a large scale in building iron ships. It is found that the constant hammering, in closing the seams and swaging the rivets, confers polarity upon the vessel, and the effect is much dependent upon the magnetic bearing of the ship while on the stocks. See MARINER'S COMPASS.

2. If the end of a steel bar be placed in contact with one of the poles of a magnet, it will become permanently magnetic by induction. A better plan is to place the bar in a line between the two opposite poles of two magnets of great intensity. — BRANDE.

3. Take a smooth bar of iron, place the middle of it on the north pole of a magnet, and draw it to the end, repeating the stroke always from the middle to the end, that is, rubbing the same way every time. Then place the middle of the bar on the south pole of the magnet and rub it to the opposite end of the bar, repeating as before.

Or take two magnets and lay them horizontally upon the bar, having their north and south poles in contact over its midlength. Then slide each toward the end of the bar. Repeat.

4. Place a horseshoe-magnet in the middle of a needle to be magnetized, with the poles turned in a direction the reverse of the poles intended to be given to the needle; then move the magnet backward and forward over and along the surface of the needle, taking care to pass over each half of it an equal number of times, and repeating the same operation on the other side: the needle is speedily and permanently rendered magnetic. — BRANDE.

We are indebted to Faraday for the comprehensive classification of all substances into *magnetics* and *diamagnetics*. A compass-needle made out of a diamagnetic would point east and west, where an ordinary compass-needle would point north and south.

In telegraphy the magnets are known by their duty or their places in the circuit, as the *sounding*, *relay*, *receiving* magnets, etc. See ELECTRICAL APPARATUS.

Mag-net'ic Bat'ter-y. A combination of bar magnets acting together.

Mag-net'ic Com'pen-sa'tor. An apparatus of iron plates, invented by Barlow, and placed near the binnacle for neutralizing the effect of ship's guns and other iron in deranging the bearings of the compass. It is superseded by the apparatus of Professor Airy, which consists of two magnets placed at right angles to each other below the compass, and a box of small iron chain. These are placed by experiment. See MARINER'S COMPASS.

Mag-net'ic Guard. A respirator with a gauze of magnetic iron to arrest particles of steel dust when dry-grinding cutlery. Invented by Abraham of Sheffield, England.

Mag-net'ic Nee'dle. A slender, poised bar or plate of magnetized steel.

The forms of magnetic needles are varied, according to fancy. Some have their greatest breadth in a vertical, others in a horizontal, direction. In surveying-instruments, $\frac{1}{20}$ of an inch broad and $\frac{1}{60}$ thick is a fair proportion; length from 4 to 7 inches, usually from $5\frac{1}{2}$ to 6. The needle is suspended by a metallic or jeweled center upon a hardened steel pivot. The test of delicacy is the number of horizontal vibrations which it will make before coming to rest. See MARINER'S COMPASS; MAGNETOMETER.

Mag-net'ic Tel'e-graph. See MAGNETO-ELECTRIC TELEGRAPH.

Mag'net-o-e-lec'tric Ma-chine'. One in which an electric current is generated by the revolution of one or more soft iron cores surrounded by coils of wire, about the poles of a magnet or magnets; or an armature (*keeper*) may rotate before the poles of stationary coils.

The first notice we find of exciting electric action by the revolution of a magnet is in a manuscript work, written in the year 1242, by an Arabian named Bailak, a native of Kibdjak. The work is called "The Merchants' Guide in the Purchase of Stones." He states: —

"Among the properties of the magnet, it is to be noticed that the captains who sail in the Syrian waters, when the night is dark, take a vessel of water, upon which they place a needle buried in the pith of a reed, and which thus floats upon the water. Then they take a loadstone as big as the palm of the hand, or even smaller. They hold it near the surface of the water, giving it a rotary motion, until the needle turns upon the water; they then withdraw the stone suddenly, when the needle, with its two ends, points south and north."

Faraday's discovery of magneto-electricity was announced in 1831. In 1833, Saxton constructed a machine of this kind, employing a commutator to cause the current to flow continuously in the same direction. The coil of wire of the armature was wound transversely to its soft iron core.

In 1857, Siemens constructed a magneto-electric machine, in which an elongated cylindrical armature, wound with insulated wire in the direction of its length, was made to revolve between the poles of a number of parallel horseshoe magnets. By this means much more powerful currents were obtained.

In 1866, Mr. Wilde of Manchester, England, conceived the idea of passing the current developed by an apparatus of this kind through the insulated wire of an electro-magnet of larger size. He found that the force of the magnetism thus excited was far greater than that of the series of steel magnets employed to generate the magneto-electric current. In

one case where these would support a weight of but 40 pounds, the electro-magnet which they excited sustained 1,088 pounds.

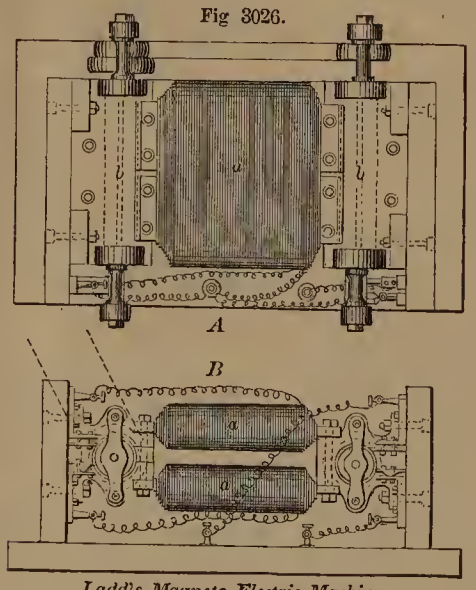
He next constructed a machine of much greater power, consisting of a series of permanent steel magnets, fifteen inches long, each weighing three pounds, and capable of sustaining a weight of 20 pounds. Their common armature is 16 or 17 inches long and $2\frac{1}{2}$ inches in diameter. It is wound with 50 feet of copper wire of $\frac{1}{10}$ inch diameter. By means of a pulley it is driven at the rate of 2,500 revolutions per minute, causing 5,000 changes of polarity in that time. The currents thus generated are turned in a common direction by means of a commutator, and sent through the wires of a large electro-magnet, which forms the base of the apparatus.

This electro-magnet is formed of two soft iron plates, 3 feet long, over 2 feet wide, and 1 inch thick, placed parallel to each other and separated at one end by a bundle of iron plates more than a foot thick, the whole secured together by bolts. At the other end is the armature, a cylinder of 7 inches diameter, deeply grooved in the direction of its length, and wound with copper wire nearly $\frac{1}{4}$ inch in diameter. More recently, Mr. Wilde has substituted insulated copper ribbon for the wire.

The armature turns in a hollow iron cylinder lined with brass, and is driven at the rate of 1,700 revolutions per minute. This machine maintains in full incandescence carbon points nearly an inch in diameter. It weighs $1\frac{1}{2}$ tons, and requires a three-horse-power engine to drive it. The currents induced by this apparatus have been passed through a second electro-magnet of still larger size, producing still more powerful effects.

Subsequently, Siemens and Wheatstone discovered means of greatly intensifying by means of its own action a very small amount of magnetism, by the rotation of a secondary coil with cores of soft iron around the poles of a magnet of very feeble power.

Fig 3026.



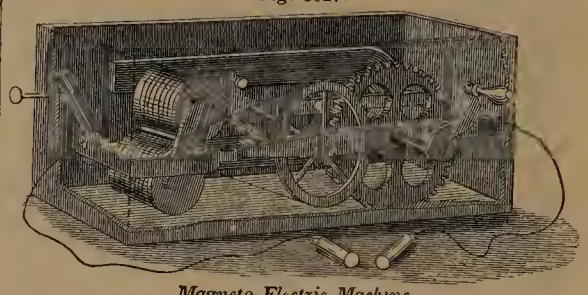
Ladd's Magneto-Electric Machine.

The induced current will also be feeble, but by being sent around the electro-magnet which produced it, its magnetism will be intensified, so that it will generate a stronger current. This again is passed through the secondary electro-magnet, and so on, the current alternately passing from the coil of the primary to those of the secondary magnet until it is intensified to a very high degree.

Ladd's machine, of which a plan *A* and an elevation *B* are shown in Fig. 3026, comprises two magnetic iron plates *a a*, surrounded by coils of wire, and having an armature *b b* at each end. The wires of one armature are connected with a commutator, and the extremities of the wire which envelops the plates are connected with tangents resting upon the commutator.

The currents generated by the revolution of the armature pass by the commutator into the wire enveloping the plates, thus tending to reinforce their magnetism; and the current, feeble at first, quickly acquires strength with the rapid rotation of the armature.

Fig. 3027.

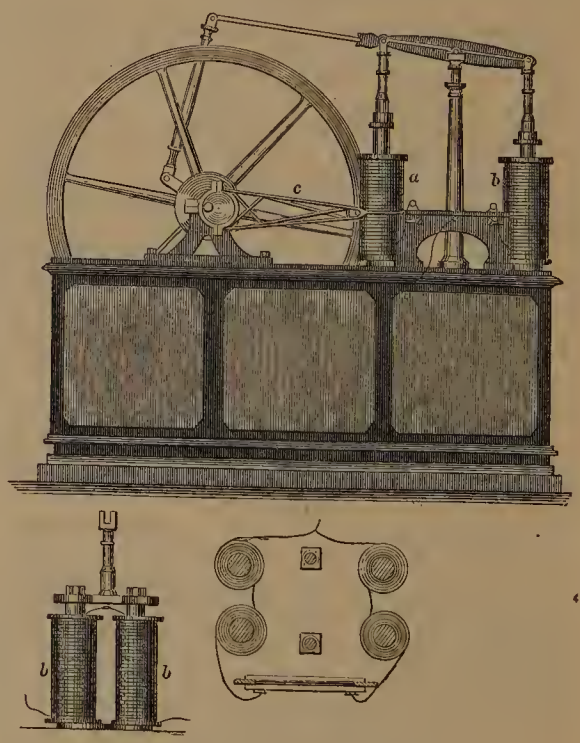


Magneto-Electric Machine.

If the other armature be now set in rapid motion, and the extremities of its helix connected with the conductors of an electric lamp, a light of intense brilliancy is produced; or platinum wire, $\frac{1}{20}$ inch in diameter, may be instantly ignited.

Fig. 3027 is a machine for medical purposes. The armature of the two magnets is rotated by a cord or

Fig. 3028.



Froment's Electro-Magnetic Machine.

belt on a small pulley, driven by a larger one which is set in motion by a hand-crank and gearing. Two conducting-wires with insulators convey the current to the parts under treatment.

Fig. 3028 represents an electro-magnetic engine, invented by M. Froment and employed by him for actuating his dividing-engine.

Four hollow cylinders *a a*, *b b*, encircled by coils of insulated wire, surround an equal number of reciprocating cores connected to the beam of the engine. Each pair of cores is connected by a transverse bar. The cylinders *b b* have their lower halves occupied by two other iron cylinders also connected together. The opposite poles of the upper and lower cylinders, which form two distinct magnets, are in reverse directions, so as to mutually attract each other. Under the influence of a voltaic battery, by suitable connecting wires, the core of the upper magnet is brought in contact with that of the lower, depressing that end of the beam, and at the same time, through the medium of an eccentric on the fly-wheel and rod *c*, actuating an ivory slider with a metallic slip on one of its surfaces, breaking the circuit thus formed, and bringing the slip in contact with a wire communicating with the electro-magnets *a a*, closing the circuit on that side and depressing the other end of the beam, which movement again opens the circuit on that side, and brings the metallic slip in contact with the circuit-wire attached to *b b*, which is again brought into action, depressing its end of the beam. A continuous reciprocating motion is thus kept up, rotating the fly-wheel through an ordinary crank and connecting-rod.

Mag'net-o-e-lec'tric Tel'e-graph. An apparatus for transmitting messages by means of an electric current excited by the rotation of one magnet about the poles of another, instead of a current excited by the voltaic action of a battery.

Professor Wheatstone's apparatus for private use in offices and manufactories is of this character, requiring no battery or chemicals.

By one of his instruments the message is printed on tin-foil in Roman characters, and dropped into a locked box till the arrival of the owner.

By another instrument the needle points to the letter itself on a dial.

Mag-net'o-graph. An instrument which registers automatically the condition and changes of terrestrial magnetism.

That in use in the Greenwich Observatory is the invention of Mr. Brooke. Two of the magnets are suspended by untwisted silk for observation in *variation*, and one upon knife-edges on agate plates for observation of the dip ; and the duty of visiting the magnets and observing their variations is attended to every two hours.

Mr. Brooke introduced an automatic plan, which is as follows : —

Around the magnets are cases of zinc which exclude the light. Inside each case is a lamp which casts a beam of light upon a mirror soldered to the magnet. This ray directed to a sheet of sensitive photographic paper records the motion of the magnet, the sheet being moved by clock-work.

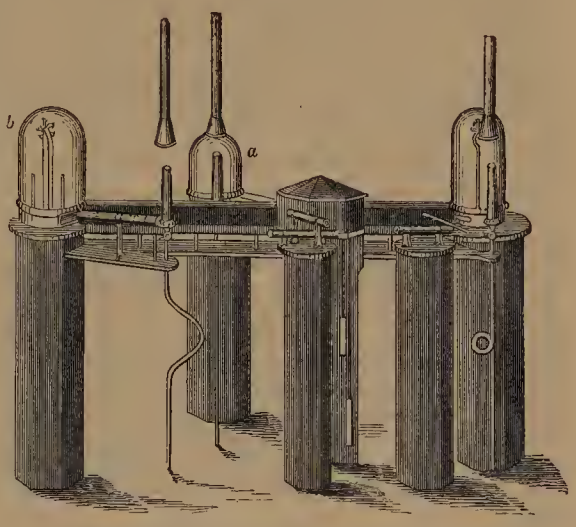
Once in twenty-four hours an assistant darkens the room, and then, with a lantern giving only a yellow ray, he removes the photographic paper, fixes the picture, and places another sheet in the case.

Fig. 3029 is a view inside of the magnetic observatory of Stonyhurst College, England, and will give an idea of the disposition of the instruments.

The instruments record the oscillations of three magnets suspended under the glass shades, and thus show completely all the changes, both as to direction and intensity, in the earth's magnetism. The magnet which is to the right in the sketch is suspended by a silk thread in the magnetic meridian, and, by the aid of a mirror attached to it, describes on a cylinder, which is put in motion by the clock on the center pier, all the variations in the magnetic declination. The other two magnets give the two components of the total magnetic force of the earth. The one *a* which records the variations of the vertical component rests on two agate edges, while the horizontal component magnet *b* is suspended by a double steel thread, and is held nearly at right angles to the magnetic meridian by the torsion of the thread.

Under the clock-box are the three cylinders covered with sensitive paper. To each magnet is attached a semicircular mirror, which sends the rays from a jet of gas to one of the cylinders in the clock-box, and thus describes, by a curved line, all the oscillations of the magnet. A second semicircular mirror is fastened to the pier on which the instrument stands, and, describing always a straight line on the cylinder which is opposite to it, gives the zero line for the curve.

Fig. 3029.



Magnetographs (Stonyhurst College, England).

Mag'net-om'e-ter. An instrument for measuring any of the magnetic elements, as the *dip*, *inclination*, and *intensity*. — Webster.

A magnetized needle, isolated from all disturbing influences and suspended by untwisted silk, is used to detect the declination, and the delicate mode of adjustment permits any variation in this element to be observed.

For observing the *dip* or *inclination* the magnetized needle is balanced by knife-edges upon agate planes, so as to vibrate like the beam of a pair of scales.

The buildings appropriated to this purpose at the Greenwich Observatory, England, are built in the form of a cross, of materials from which iron is rigidly excluded. In two arms of the cross are magnetized needles suspended by silk, for observations in declination or *variation ;* and in another arm of the cross is a balanced needle, for observations in inclination or *dip*. The arrangements were under the control of Mr. Glaisher, and the observations were originally made by himself and two assistants, until Mr. Brooke introduced his adaptation of photography to the purpose of recording observations. By means of mirrors attached to the arms of the magnets, reflected light is cast upon highly sensitized photographic paper wound round cylinders moved by clock work, and the slightest variation of

the magnets is registered with the greatest accuracy. See MAGNETOGRAPH.

We shall have occasion to show that the mariner's compass originated in China, and came thence through India and Arabia to Europe. The Chinese annals show that it was used by them nearly 3,000 years ago, — first on land, then on water. Humboldt remarks the singular fact. It was used at sea by the Chinese as early as the era of Alexander the Great. No mention is made by his historians of the wonderful instrument, although they have not forgotten to note that he was met by a people with storms of lightning and thunderbolts; another Chinese invention, — gunpowder.

The original mode of suspending the needle was by flotation, several devices being used for this purpose, such as burying it in pith, laying it on a couple of floating sticks, etc. These plans gave the needle freedom of motion in a horizontal plane and sufficed apparently for many ages. The same plan was adopted in Europe for several centuries. See p. 1371.

About the twelfth century of our era, or earlier, the Chinese introduced the mode of suspending the needle by a silken string. This delicate adjustment allowed other elements of terrestrial magnetism to be observed; and during the thirteenth century the Chinese philosopher, Keon-tsoung-chi, observed the variation of the needle from the cardinal points to the extent of 2° to 2° 30′. The French savans in Pekin, a few years since, determined it to be about the same. In common with all European nations the variation was spoken of by the Frenchmen as a variation from the north towards the west; but the Chinese, who respected the south more than the north, considered that the needle pointed south, and counted from that pole of the magnet, calling the declination a variation to the east of south. This is the same thing in effect. The order of the Arabic words *zoron* and *aphron*, *south* and *north*, show whence the Arabs derived the invention. See MARINER'S COMPASS.

The variation was again noticed by Columbus in 1492, and Sebastian Cabot in 1540.

It does not appear that the other element of terrestrial magnetism, the inclination or dip, was known to the Chinese, though they must surely have noticed that a needle which hung in perfect equipoise before magnetizing was thrown out of balance when touched by the loadstone.

Robert Norman of London, a maker of compasses, was the first, so far as we know, to detect the *dip* and publish the fact; 1576. He contrived the *dipping-needle*, suspended on a horizontal axis, and found the *dip* at London to be 71° 50′.

Robert Halley, in 1700, published a chart, having lines passing through points of equal magnetic variation. His remark was that of a philosopher: —

"The nice determination of the variation, and several other particulars in the magnetic system, is reserved for a remote posterity All that we can hope to do is to leave behind us observations that may be confided in, and to propose hypotheses which after-ages may examine, amend, or refute."

Magnetic changes made Halley's chart obsolete in forty years, and it was reconstructed by the joint efforts of the English navy, East India Company, and Hudson's Bay Company. This chart was not satisfactory, and its discrepancies became positive inaccuracies as time wore on.

About 1756, John Canton, in England, made about 4,000 experiments for discovering and explaining the cause of the diurnal variation of the needle.

La Peronse sailed from France with instructions and instruments, intending to make special observations at remote stations in regard to the *variation* and *dip* of the needle. The lamented death of the Admiral and destruction of his vessels in 1788 prevented the results from being communicated to the scientific world.

M. Hansteen of Denmark undertook the subject in 1811, and in 1819 published his celebrated work "Upon the Magnetism of the Earth." He treated the matter historically and scientifically, making a variation chart for 1787.

The *agonic line*, or line of no variation, where the magnetic and geographical lines coincide, was discovered by Columbus in 1492, about 100 miles west of the Azores. Like other magnetic lines, it appears to have shifted. Hansteen's observations confirmed in great detail the position of Halley, that "the whole magnetical system is in motion; that the moving force is very great, extending its effects from pole to pole; and that its motion is not sudden, but gradual and regular."

The western line of no variation in Hansteen's chart, calculated for 1787, begins in latitude 60° to the west of Hudson's Bay, proceeds southeast through the North American lakes, passes the Antilles and Cape St. Roque till it reaches the South Atlantic Ocean, where it cuts the meridian of Greenwich in about 65° south latitude.

The eastern line of no variation (1787) is extremely irregular, having curious curves and contortions, indicating the action of local magnetic forces. It begins in latitude 60° south, below Australia; crosses that island, extends through the Eastern Archipelago with a double sinuosity so as to cross the equator three times; first passing north of it to the east of Borneo, returns, passing south between Sumatra and Borneo, and crossing the equator again south of Ceylon, from whence it passes to the east through the Yellow Sea. It then stretches along the coast of China, making a semicircular sweep to the west till it reaches the latitude of 71° north, when it descends again to the south, and returns north with a great semicircular bend which terminates in the White Sea.

Captain Sir James Ross reached the magnetic pole, latitude 70° 5′ 17″ north, and longitude 96° 46′ 45″ west, on the 1st of June, 1831. The amount of *dip* was 89° 59′. Horizontal needles refused to work, showing no sensitiveness. He erected a cairn of limestone rocks, inclosing a tin case with the record. The cairn may remain, unless the Esquimaux have removed it in search of plunder, but the magnetic pole has moved away.

The illustrious Humboldt gave the first start to a regular, systematic mode of recording magnetic observations, taking a large number in the course of his extensive travels and explorations, and calling the attention of the scientific world to the mode and importance of so doing.

Observatories, provided with magnetometers and meteorological instruments, and with apparatus for ascertaining the time and true meridian, are now working in concert in many distant stations: Berlin, Paris, Freiburg, Greenwich, Gottingen, Montreal, Melbourne, Cape Town, St. Helena, Simla, Madras, Bombay, Singapore, and probably many other places.

It is understood that the observations are made at the same instant of absolute time. Each day is divided into 12 equal periods of 2 hours each, termed the magnetic hours. The mean time at Gottingen is adopted; a tribute to the energy and skill of M. Gauss of the observatory in that city.

Mr. Brooke's system of photographic registry is adopted throughout.

Mag'net-o-mo'tor. A voltaic series of two or

more large plates which produce a great quantity of electricity of low intensity, adapted to the exhibition of electro-magnetic phenomena. — BRANDE.

Mag'ni-fy-ing-glass. A popular term for a convex piece of glass or a lens which has the property of magnifying. See OPTICAL INSTRUMENTS.

Mag'nus-hitch. (*Nautical.*) A kind of knot used on board ship.

Ma-goo'tee. An instrument used by the Pambatees or snake-charmers of the East Indies.

It is composed of a hollow calabash, to one end of which is fitted a mouthpiece similar to that of the clarinet. To the other extremity is adapted a tube perforated with several holes, which are successively stopped by the fingers, like those of the flute, while the player blows into the mouthpiece. In the middle of the instrument is a small mirror, on which the serpents fix their eyes while dancing.

Ma-ho'vo. An adaptation of the fly-wheel to the conservation of power during the times of light strain, to be used during periods when a greater power is needed. The invention of Captain C. Von Schubersky of Russia. See FLY-WHEEL.

Maid'en. A machine for beheading.

The Scotch guillotine, in use from 1550 to 1680, was copied from one at Halifax, England. It was sometimes called the *widow*. Both terms of grim and gross pleasantry.

The Halifax machine was an importation (as to design) from Italy, where it was used in the thirteenth century. Conradin of Swabia was decapitated by the *mannaia* at Naples, 1268.

The machine is supposed to have originated in Persia.

It was used in the execution of the Duc de Montmorenci at Toulouse, 1632. By the Germans during the Middle Ages, and by the Dutch in their colonies.

The Scotch *maiden* was imported into Scotland by the Regent Morton, who died by its axe, 1581. The murderers of Rizzio were executed by it in 1566; and the Marquis of Argyle, 1681.

The *maiden* was not as complete an instrument as the *guillotine*, which has a turning plank and track, with other devices for an artistic performance of tragedy. See GUILLOTINE.

Mail. 1. (*Weaving.*) One of the small brass eyes through which the *end* or worsted yarn passes in a *Brussels carpet-loom*, and by which it is lifted in order to form the loop which distinguishes the surface of that variety of carpet. See BRUSSELS-CARPET.

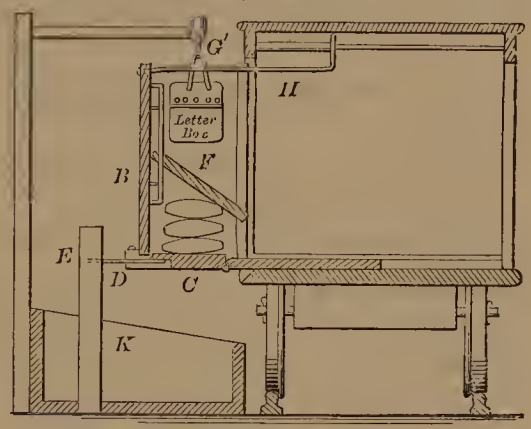
2. (*Nautical.*) A device consisting of interwoven rings, like mail-armor, used for rubbing off the loose fibers on cordage.

3. (*Armor.*) A flexible armor of rings or scales, covering the body or body and limbs, according to its extent.

Mail-bag. A letter-bag, usually of leather, but made of canvas, for containing newspapers and other printed matter for conveyance through the post-office. When of leather, the joints are closed with rivets; when of canvas, the seams are felled. The fastening of the mouth is by staples on one portion, which project through slits in the other, a strap being rove through the staples and locked.

Mail-bag Re-ceiv'er and Dis-charg'er. A device for receiving mail-bags from or delivering them to railway-cars in motion at stations along the road. Fig. 3030 shows one form of the device, in which the rod *H* attached to the car strikes the suspended mail-bag and draws it from the hook *G'*, when it falls upon the hinged incline *F* and is delivered into the car. In this way the mail is received by a car while under full headway, and simultaneously mail is delivered from the car by means of the trap-door *C*. The door *C* is disengaged by an arm *D*, which comes in contact with a post *E*, and the bags fall into the box *K*. When the receiving and deliv-

Fig. 3030.



Mail-Bag Receiver and Discharger.

ering are done, the section *B* is slid back into the car.

Worsdell's apparatus for receiving and delivering mail-bags and express matter to and from railway-cars, English patent, January 4, 1838. The bags to be delivered are suspended by their loops from two pins in a bar projecting from the carriage, from which bar also projects a prong or hook, and the bags to be received at the station are suspended from similar apparatus attached to a lamp-post. By the passage of the carriage past the lamp-post, the hook on the latter passes through the loops of the car bags and bears them off the pins, while the hook on the car in like manner carries off the bags from the station.

Other plans have scoops or cylinders on the car which pocket the mail-bag suspended from a crane or lying upon a support from which it may be shoveled, picked, or shot by the device on the car. A somewhat similar converse arrangement deposits at the station the bag carried by the car.

Mail-coach. A carriage chartered by the post-office department or hired to carry postal matter.

Mail-coaches were introduced by Robert Palmer of Bristol, England, in 1784.

Mail'ing-ma-chine'. A machine for attaching addresses to newspapers, etc., for transmission by mail. See ADDRESSING-MACHINE; also, Ringwalt's "Encyclopædia of Printing," pp. 226, 227.

Mail-net. (*Fabric.*) A form of loom-made net, which is a combination of common gauze and whip-net in the same fabric. The whole fabric is a continued succession of right-angled triangles, of which the *woof* forms the basis, the *gauze* part the perpendiculars, and the *whip* part the hypotenuse. The gauze and whip parts are stretched on separate beams.

Main. A principal part or portion.

1. (*Hydraulics.*) *a.* A large or principal water or gas pipe. The smaller are termed *supply* or *service* pipes or branches.

b. A large channel or ditch.

2. A banker's shovel for coin.

3. (*Nautical.*) The middle or prineipal mast, hatchway, etc., in a three-masted vessel.

In all *two-masted* vessels, except the *yawl* and *ketch*, the main is the aftermost mast. A *brig* or *schooner* has a fore and a main mast.

With a *yawl* or *ketch*, the forward mast is the

larger, and is called the *main*-mast, the other being the mizzen.

In all rigs the main-mast is the principal and tallest mast.

The term *main* characterizes the sails, yards, booms, standing and running rigging, and other furnishing of the main-mast; such as *main sail* and *yard*, *main-topsail* and *yard*, *main-topgallant*, *main-royal*, *main-boom*, *main-stay*, *main-top*, *main-sheet*, etc.

The term is also applied to objects in the vicinity of the mast; as, the *main-hatchway*, *main brace*, *stay*, *keel*, etc.

Also to principal parts which are of central position, greater size, prominence, or importance; as, *main-deck*, *main-keel*, *main-breadth*.

In other than nautical matter the word is similarly characteristic.

Main-breadth Line. (*Shipbuilding.*) A line on the surface of the vessel cutting each of the cross sections at the point where its breadth is greatest.

In vessels having a "straight of breadth" vertically, there are two main-breadth lines, at the upper and lower boundary of the straight of breadth respectively.

Main-cen'ter. (*Steam-engine.*) In side-lever engines, the strong shaft upon which the side-levers vibrate.

Main Check-valve. (*Steam-engine.*) A valve belonging to the Giffard injector, to prevent water running out of the boiler should anything go wrong with the injector.

Main-coup'le. (*Carpentry.*) The principal truss in a roof.

Main-deck. (*Shipbuilding.*) The deck next below the *spar-deck* in frigates and 74's.

Main-ham'per. A large hand-basket.

Main-in-clos'ure. (*Fortification.*) The body of the place.

Main-links. (*Steam-engine.*) The links in the parallel motion which connect the piston-rod to the beam of a steam-engine.

Main-piece. (*Shipbuilding.*) *a.* The principal piece of the head. It is stepped into the stem-piece, and is notched for the reception of the heel of the bobstay-piece. See STEM.

It is also called the *lace-piece*.

b. The longest piece of the rudder, to which the helm is attached.

Main-pin. (*Vehicle.*) A *bolster-pin*; *king-bolt*.

Main-plate. The principal plate of a lock.

Main'spring. 1. (*Horology.*) The going spring of a watch, spring-clock, musical-box, alarm, or other spring-driven instrument.

Fig. 3031.

Mainspring.

In the watch, it is termed main, because of its major importance, and to distinguish it from the pendulum or balance-spring, which gives the recoil movement to the balance.

2. (*Fire-arm.*) The spring in a gun-lock which drives the hammer.

Main-work. (*Fortification.*) The enciente or principal works inclosing the body of the place.

Mait'land Cord. (*Weaving.*) A cord extending along the wooden shafts of leaves, to which the heddles are fastened with knots.

Ma-jol'i-ca-ware. A species of fine pottery, composed of clay thickly and opaquely enameled, suitable for receiving brilliantly colored figures; fabricated at Ferrara (1436) and at Passaro (1450). It is sometimes called "*Raffaelle* ware"; this may be from the fact that Raffaelle Sanzio d'Urbino furnished designs for the ornamentation of some specimens, or from one Raffaelino del Colle, a skillful workman at Urbino. The name is a corruption of *Majorca*, into which island (in the twelfth century) the Moors introduced the manufacture of a species of ware decorated with brilliant colors.

Majolica, until the time of Lucca della Robbia, was glazed with a plumbiferous glaze (*mezza majolica*), but Robbia invented a beautifully white, durable, enameled, stanniferous glazing. Giorgio, by the combination of mineral colors, succeeded in producing beautifully iridescent ruby and golden tints. Existing specimens of his manufacture are very costly. After the time of Fontana (about three hundred years ago), who carried the manufacture to perhaps its highest perfection, the art began to decline, the production finally ceasing altogether.

Of late years, the Staffordshire potters have succeeded in reproducing this ware, and slabs, friezes, tablets, vases, flower-pots, and other articles are now made of it.

Make-up. (*Printing.*) To break matter in columns or galleys into suitable length for pages.

"Mak'ing"-felt. (*Paper.*) That felt of a cylinder paper-machine on which the web of pulp is taken from the *making*-cylinder, at the point where the couching roller bears upon the latter. In contradistinction to a mere *carrying* felt.

Mak'ing-i'ron. (*Shipbuilding.*) A large calking-iron with grooves lengthways of its face, used for the final driving of oakum into the seams. The iron is held by one man, and driven by another by means of a beetle; the process is called *horsing-up*. A *horse-iron*. After the making-iron, the seams are payed with melted pitch.

Mal'a-chite. *Mountain green.* A native carbonate of copper.

Ma-lax'a-tor. A mixing-mill. A cylinder having a rotating shaft and stirring-arms to incorporate materials.

Coignet's *malaxator* for incorporating the ingredients of his concrete (see BÉTON) is supplied with the materials in graduated proportions, the energetic working permitting the use of a much smaller quantity of water than usual.

Mortar-mills, *pug-mills*, and many other machines come under this description, e. g. machines for mixing the ingredients of pills.

Hyde's soap-making machine, 1870, is an instance in which the grease, resin, and lye are incorporated by a revolving stirrer in a cylinder, the operation being continuous.

Mal'kin. A sponge with jointed staff for ordnance.

Mall. A heavy beetle. See MAUL, and Fig. 3031.

Mal'le-a-bil'i-ty. The quality of adaptedness to be drawn into thin plates by hammering; as *ductility* is the wire-drawing capacity. See DUCTILITY for comparative statement.

Mal'le-a-ble Cast-i'ron. Iron cast from the pig into any desired shape, and afterwards rendered malleable, or partially so, by annealing.

A great variety of articles are thus produced in a more economical and correct manner than they could be by forging. Such are bridle-bits, snuffers, parts of locks, various forms of builders' and domestic hardware, some kinds of culinary and other vessels, pokers, tongs, and numerous other things. Many of these are subsequently case-hardened and polished.

The art of softening cast-iron and working it, and

afterwards hardening it again, appears to have been found out by Reaumur, though we have no record of the process by which it was effected.

Malleable-iron castings are rendered externally soft by the abstraction of carbon, by which they are reduced nearly to the condition of pure malleable iron, but do not possess the fibrous structure which is acquired by hammering and rolling.

In England they are made from the rich Cumberland iron, and are at first extremely brittle. To render them malleable, they are inclosed in iron boxes and surrounded with pounded iron-stone, or some of the metallic oxides, as scales from the forge, common lime, or some absorbent of carbon, used either together or separately. The boxes are placed in the furnace, subjected to a strong heat for about five days, and allowed to cool gradually within the furnace.

The time and other circumstances determine the depth of the effect; thin pieces become malleable entirely through, admit of being readily bent, and may be slightly forged; thicker pieces retain a central portion of cast-iron, but in a softened state, and not so brittle as at first. On sawing them through, the exterior coat of soft metal is perfectly distinguishable from the remainder.

The inventor of the process of rendering articles of cast-iron malleable was Samuel Lucas of Sheffield, by whom it was patented in 1804.

As described in his specification, his process was nearly identical with that above described, except that the castings were placed directly in the furnace, instead of being inclosed in boxes.

The Siemens regenerative gas furnace is largely used in England now for heating the annealing-oven in which the crucibles containing the cast-iron articles are placed.

As arranged for this purpose, the furnace has four longitudinal main flues divided by partitions into a number of smaller flues. The two exterior flues receive the heated gas and the two interior ones hot air. Over these is a closed arched muffle, in which the annealing-pots are placed. The hot gas and hot air, being kindled, pass beneath at the sides and over the top of the arch of the muffle.

The furnace is never permitted to cool entirely. The pots are allowed to cool on the floor.

The German makers of malleable-iron castings are said to use a pig-iron measurably free from sulphur and phosphorus, which they melt in plumbago crucibles with porcelain covers, containing about 30 kilogrammes (66 pounds). No blast is used; the natural draft of the furnace-chimney being considered sufficient. A high heat at the moment of pouring is essential to a successful cast, and the precise moment for this operation is ascertained by plunging a bar of red-hot iron into the crucible. The crucibles are raised by tongs, and the pouring performed as quickly as possible. When sufficiently cool, the castings are placed in boxes alternately with layers of red hematite, and subjected to the heat of the furnace for from 3 to 5 days, according to size, and removed after the furnace has been allowed to gradually become cool.

An approved mode in the United States of rendering castings malleable is as follows: —

When taken from the mold they are washed with dilute sulphuric acid to remove the rough coating of vitrified sand from their surfaces, and the ragged burrs sometimes left at the junction of the two parts of the mold are chipped off, after which they are packed with the "scale," derived from iron bars in the process of rolling, in square iron boxes (technically called *pots*) of the dimensions of about 15 × 18 inches, of which one is placed on top of another, the joints carefully luted. They are inserted into the furnace in pairs, and subjected to a cherry-red heat for about eight days; the heat is somewhat slackened toward the latter part, after which the doors are thrown open to allow them to cool. When removed from the pots the castings are coated with a rough crust, which is removed by abrasion in tumbling-boxes.

Mal'le-a-ble I'ron. Iron sufficiently pure to be drawn out into bars and welded.

Iron, in the ore or roasted, is in the state of oxide, and (omitting from the consideration the presence of foreign matters) to obtain it pure merely requires the separation of the oxygen. This may be done as a chemical process by heating the oxide to a heat below redness in a glass tube through which hydrogen is then passed; the hydrogen and oxygen unite to form aqueous vapor, and pure iron remains. This is measurably true of certain qualities of ores, but pig-iron is sometimes found to contain 10 to 18 per cent of foreign matters, — principally manganese, carbon, and silicon, — also phosphorus and sulphur, both of which latter it is almost impossible to entirely remove by puddling.

All these have to be got rid of to produce pure malleable iron, unless the ore is of extraordinary purity.

At a moderate red heat, a mixture of finely pounded charcoal and oxide of iron will have the effect of eliminating the oxygen, and this process is believed to have been in use in ancient times in the island of Elba. The ore is remarkable for its freedom from earthy impurities, and after breaking into small pieces was imbedded in charcoal on the floor of a reverberatory furnace. After the oxygen was separated by the action of the charcoal, the temperature was raised to a welding heat, and the pieces of ore, now in the state of porous iron, were caused to adhere by hammering, and were drawn into bars. This is a process of obtaining malleable iron direct from the ore, and has been repeated by Mushet.

There is considerable analogy between this and the native East-Indian practice, where the broken ore or magnetic-iron sand is placed in alternation with bamboo charcoal, and a pasty mass of crude iron obtained, whose malleability is sometimes sufficiently great to enable it to be hammered into small bars without a second operation. The bellows used are made of skin, are worked alternately, and discharge by separate holes through the clay tuyere which is introduced at an angle near the bottom of the upright furnace.

These Indian furnaces are miniatures of those in Styria, described in the work of Jars, a French metallurgist, 1750. The ores there worked have a notable percentage of manganese, which affects the result, being seemingly favorable to the retention of a certain amount of carbon, but resisting the combination of the larger amount necessary to make cast-iron.

Styria was not the only European country in which the simple furnace just described was used for smelting iron ore, for those of Sweden and Norway, 300 years ago, were of substantially the same character. The iron obtained from them was a spongy mass, which was drawn out at intervals by tongs, hammered gently and cautiously, and then more energetically, to press the particles of iron into contact and squeeze out the intermixed slag. The mass thus obtained was cut up into smaller pieces, which were repeatedly heated and hammered till a sound bar of nearly pure iron was obtained.

The size of the furnace, and especially its hight,

was increased in order to save fuel, as the ore and flux piled in above were heated by the outgoing caloric current, preparatory to being subjected to the direct action of the blast. The bellows were also proportionately increased in power. This change, probably adopted from motives of economy, changed the result, and rendered necessary new processes to bring the iron to a malleable state. As the iron descends through the furnace for 30 feet it is subjected to the action of the fuel, and has time to part with its oxygen, and also absorb from 3 to 5 per cent of carbon and 2 to 4 per cent of silicon. This addition renders it more fusible, and it sinks to the bottom of the crucible in a carbonized state, differing in respect of its greater proportion of carbon from the spongy and less fusible mass of iron, such as was produced by the processes above referred to as carried on in ancient times in Elba, both anciently and more lately in India and Styria, and elsewhere.

This clears up much of the difficulty in the reading of the ancient records, where iron always appears in a malleable form, the tools used by the workers in iron consisting invariably of the bellows, hammer, and anvil. It appears that fusible cast-iron was first considered immediately useful after the size of the furnaces had been so increased as to prevent the production of the more or less malleable and purer article incident to the furnaces on a small scale, which we have just above cited.

The new production, instead of remaining a spongy mass in the midst of the coal and slag, to be hauled thence by tongs and be subjected to the hammer to clear it of foreign matter and condense it, ran down like a fluid to the bottom hearth, and found its way out of a hole, running into a form according to the shape of the hollow in the ground which received it. By this means the smelter found he could withdraw the iron, without tearing out the front of his furnace for each bloom.

This new form, cast-iron, being brittle under the hammer and unsuitable for almost all the known uses of iron at the day when the discovery was made, it became necessary to subject it to a farther process, in order to burn out the greater portion of the carbon and silicon and render it malleable. The refining process observed by M. Jars in Sweden, in 1750, is identical with that described by Aiken in 1836 as having been used in India for a length of time not now readily ascertained.

The block of crude iron is laid, covered with charcoal, on the floor of the furnace, with one end projecting over the crucible, a little above the mouth of the tuyere. In this situation the block softens and soon falls down in a state of half-fusion ; a man with an iron bar then draws the remainder of the iron block forward, advancing it from time to time, till the whole has fallen into the crucible.

It is then dragged out, glowing hot, and hammered on an anvil to separate the scoriæ ; being divided, it is again heated and hammered until it is rendered quite malleable.

A modification of this process was adopted in Sweden, being derived from the puddling process of Cort, and consisted in covering the metal in the crucible with scoriæ and stirring it continuously with an iron bar. Jets of flame arose, and the metal solidified. Berzelius explained the action in this way : The scoriæ contained oxide of iron vitrified with silica and other earthy substances containing oxygen, which, reacting on the carbon of the iron, separated it in the form of carbonic oxide.

More modern forms of refining have superseded the Indian and Swedish plans above cited, the broken pig-metal being placed on the hearth of a furnace, covered with coke and slag, and a blast turned on till the metal is melted. It is run into slabs, and the metal obtained is white, hard, compact, and brittle.

The puddling-furnace was invented by H. Cort of Sheffield, England, his patent being dated in 1784. See PUDDLING-FURNACE.

One process of converting pig into malleable iron, as practiced in England, is as follows : —

The pigs are melted in the fining-furnace, by which the iron is deprived of part of its carbon and a larger portion of its silicium. The molten metal collects in a cavity at the bottom of the hearth, and is drawn off into a cast-iron trough in which it speedily cools. By this process it is converted into a white cast-iron termed *fine metal*. This is broken up and transferred to the puddling-furnace, in which the decarbonization is completed.

The puddling-furnace is of the reverberatory class, and is provided with openings for working the metal while in a fluid or semi-fluid state, and for charging and clearing the furnace.

The charge of *fine metal* is piled up on the sides of the hearth, the center of the sole being left clear for working and allowing a circulation of air around the charge. A portion of rich slag and iron scales is added. As the metal melts, it is stirred with an iron rod, so as to expose fresh portions to the air until the whole mass is brought into a uniform pasty condition, when the fire is lowered. The metal is constantly stirred with an iron paddle, gradually losing its consistency, until it becomes sandy or *dry*, as it is termed by the puddler, who continues to work it until it becomes uniformly granular.

The heat is then increased, causing the particles to agglutinate. A part of the slag is drawn off, when the workman proceeds to *ball up*, that is, to form the iron into balls. This is effected by taking up a small portion on the end of the paddle, which is manipulated so as to cause other portions to adhere to it until a ball has been formed weighing 60 or 70 pounds. This is detached from the paddle, and other balls formed in a similar manner until the whole charge has been balled. When this has been done, each ball is moved into the hottest part of the furnace by means of a kind of rake called a *dolly*, and the fire is urged in order to weld the particles together. The balls are then removed from the furnace by means of tongs and conveyed to the *shingling-hammer* or the *squeezer*, by which the slag is pressed out and the metal consolidated. In this state the ball is called a *bloom ;* and while it is still at a red heat it is passed between two sets of rolls, the first called the *roughing*-rolls and the second the *finishing*-rolls, which latter are grooved corresponding to the section to be given to the bar.

The iron in this state is adapted for railway rails, which are made by successively drawing the bar through rolls of section similar to that of the rail, but gradually decreasing in size. To produce good bar-iron, the bars from the roughing-rolls are cut into short lengths by shears, and *piled* or *fagoted* together in a reverberating furnace until they are at a welding-heat, when they are drawn through a series of finishing rolls of section adapted to the required shape of the bar. See PUDDLING-FURNACE ; ROLLING-MILL ; IRON, ANGLE, etc.

Mal'le-a-ble-i'ron Cast'ings. Small cast-iron articles are made malleable, their brittleness being thus removed, by packing them in powdered hematite (peroxide of iron) in tight fire-brick cases, and subjecting them to a continued red heat for about a week. They are then allowed to cool slowly.

The oxygen of the hematite combines with and removes a part of the carbon of the iron.

It is the converse of the process in which wrought-iron is closely packed with charcoal in a converting furnace, in order that its deficiency in carbon may be supplied, converting the bar-iron into steel. See MALLEABLE CAST-IRON ; CEMENTING-FURNACE.

Mal'let. 1. A hammer of wood, smaller than a maul. Formerly, in the absence of metal, *celts* or hammers of stone were used. Mallets and wedges of stone were used in ancient Egypt, and were found in the pyramids of Cheops and Ghizeh.

Fig. 3032.

Mallets, Mauls, and allied Tools.

Among other remnants of other centuries, gathered by Mr. Burton in Egypt, he found an old mallet in Thebes ; it was in a basket along with drills, bow, chisels, an oil-horn, a saw, and a nail-bag, and had been locked up in a dry and dusty tomb at a time when Greece had not felt the light of science, and centuries before Romulus and Remus. Perhaps the workman had been putting the finishing touch to some of the fittings of the tomb, and accidentally left it inside when the door was closed, as they supposed, forever, or until the shell of the body was revived to receive its old tenant. The successors of the carpenter in the twentieth generation may have suffered from the wrath of Cambyses.

a b c d are chisels and drills.

c a drill-bow, the leather string lost.

f, whorl of the drill. *g*, saw ; *h*, hone.

i, oil-horn ; *j*, mallet, much worn.

k, skin nail-pouch. *l*, the basket in which the tools were contained.

The collection belonged to Mr. Burton, and is now in the British Museum.

The modern mallet is preferably of boxwood, but apple-tree, pear-tree, dogwood, gum, beech, or locust makes good mallets. *v* is a mallet made of thicknesses of raw-hide firmly pressed together by the center bolt. *w* has a rubber body upon a metallic skeleton.

2. (*Nautical.*) *a*. A *calking-mallet* is one used with a *calking-chisel* or *making-iron* to drive oakum into the seams of a vessel.

b. A *serving-mallet* is a cylindrical block of wood, by which spun-yarn is tightly coiled around a hawser or rope.

3. (*Dentistry.*) A plugger for compacting filling in carious teeth. See DENTAL-PLUGGER, Figs. 1610, 1611.

4. A striker for balls in games. A *croquet* mallet.

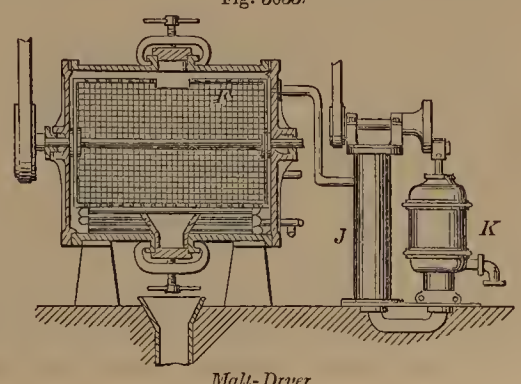
The *electric mallet*, in which the impulse is given by means of a galvanic circuit acting upon a magnet to oscillate an armature, or to move the magnet itself to and from an armature which forms the punch, is described under PLUGGER.

5. (*Surgical.*) A hammer used with a gouge in cutting bones.

Malm-bricks. The name given to those bricks, made in the neighborhood of London, in which the clay is pulped, mixed with cream of lime, and incorporated with breeze before molding. Breeze is a casual mixture of cinders, ashes, and fine coal, such as is gathered by the dustmen of London, and forms a part of the combustible material by which the bricks are burnt in the clamp. See BRICK.

Malt-dry'er. A device to hasten the drying of malt by artificial heat. Fig. 3033 shows a machine in which the malt is agitated and overturned in an

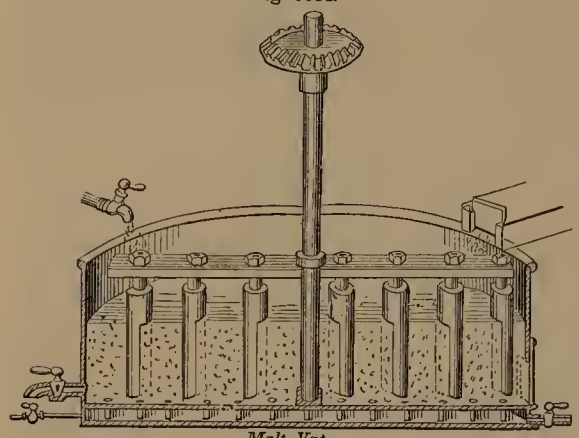
Fig. 3033.



Malt-Dryer.

air-tight vessel from which all moisture is withdrawn by an air-pump, while its contents are exposed to heat. The wire-gauze cylinder *F* is within the air-tight vessel, and is caused to revolve, and so stir and mix its contents. *K* is the air-pump and *J* a condenser. The air-tight vessel has man-holes above and below, secured by man-hole covers and bridges, through one of which the malt is received, and discharged into the hopper below by the other.

Fig. 3034.



Malt-Vat.

Malt-floor. The floor of an *oast* or malt-drying room.

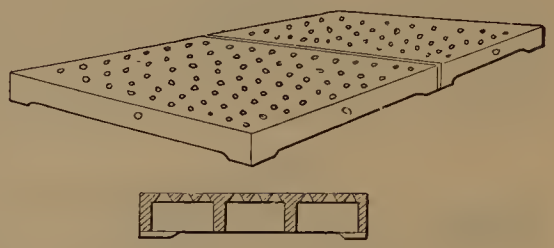
Malt'ing-ap'pa-ra'tus. (*Brewing.*) A vessel in which ground malt is steeped to make the infusion known as *wort;* this, with the addition of decoction of hops and fermentation, becomes beer. The malting-vat shown in Fig. 3034 is provided with a false bottom, forming a steam-chest. Within the vessel revolves a shaft armed with blades. A portion of the blades are so set as to move the grain towards the circumference, and the other blades are so arranged as to move the grain towards the center.

Malt-kiln. A heated chamber in which malt is dried, in order to check the germination of the grain after having undergone the preliminary processes of *steeping*, *couching*, and *flooring*. An *oast*.

In the first of these processes, the barley is placed in a cistern, and sufficient water let in to cover it. This water is changed after having remained a certain time, to avoid fermentation. When the grain has steeped until it has imbibed the proper quantity of moisture, — in England the law requires that it shall remain in steep forty hours, — during which time it greatly increases in bulk and weight, on an average nearly fifty per cent, it is removed from the cistern and arranged in a rectangular heap called the *couch*. Here it remains about 26 hours, gradually increasing in temperature and parting with its moisture. During this process small roots begin to make their appearance. The growth of these is checked and the temperature of the heap lowered by *flooring*, or turning and spreading it out into a thinner layer, gradually reducing its depth from 16 to 3 or 4 inches. The flooring occupies about 14 days. About a day after the sprouting of the roots, the stem begins to make its appearance, and is allowed to grow until it reaches the end of the seed, when its farther progress is stopped by drying in the kiln.

The ordinary kiln is a chamber floored with a perforated iron plate, and having a vent in the roof for the escape of fumes. This is heated by a furnace in an apartment below, the hot air rising through the holes in the iron plate and passing through the malt. The temperature is at first about 90°, which is afterwards increased to 140° or more. For the completion of this process about two days should be allowed, during which the roots fall off and are separated from the grain by allowing the latter to run down a shoot, at the end of which is a screen which does not permit the grain to pass. The malt is then spread out to mellow or become soft and mealy by a slight absorption of moisture.

Fig. 3035.

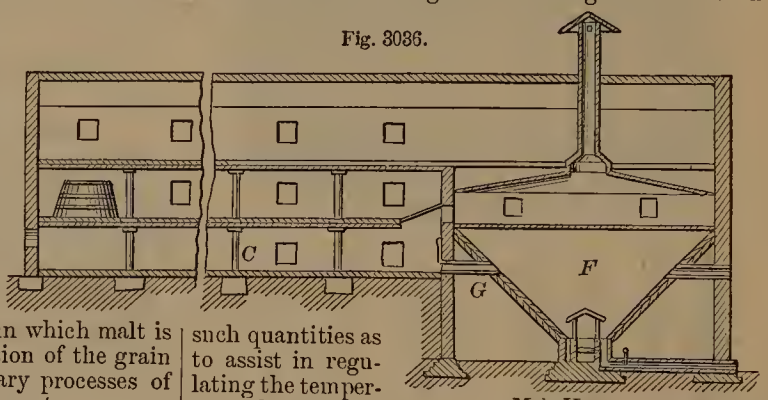


Malt-Kiln Floor.

Fig. 3035 shows part of a floor composed of plates made of malleable cast-iron, strengthened on their under side by ribs crossing each other at right angles and uniting with a marginal ledge surrounding them, so as to be bolted together to form the floor.

In the kiln, Fig. 3036, air for supply of the furnace is drawn through the malting-chamber *C* in such quantities as to assist in regulating the temperature, by means of draft pipes or tubes *G* connecting the chamber with the heating-chamber *F* of the kiln.

Fig. 3036.



Malt-House.

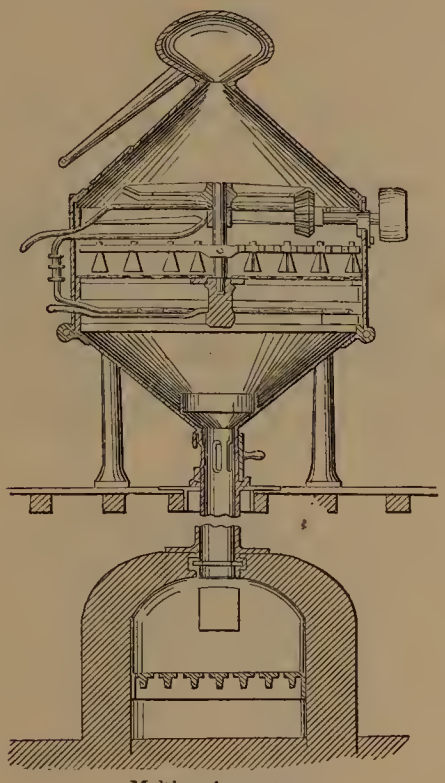
In the apparatus, Fig. 3037, the grain is stirred and turned by mechanical means, while exposed to the heat of the kiln. A furnace below and layers of steam-pipe within heat the kiln, and the vapor generated is condensed in a separate chamber, which connects by a pipe with the dome.

Man'a-cles. Handcuffs or *nippers* for criminals. The two pieces of metal are hinged together, the upper portion of which is curved so as to fit the wrist, and the lower portion is straight except at a point near its outer end, where it is slightly bent. Fig. 3037.

Man'da-rin'ing. Giving an orange color to silk or wool by the action of nitric acid, which partially decomposes the surface of the fiber.

Man'do-lin. (*Music.*) A stringed instrument played by the hands. It has 4 double strings, that is to say, four times two strings in unison and tuned in fifths like the violin. It is written on the G clef. The E strings are of catgut; the A strings of steel; the D strings of copper; and the G strings of catgut covered with silver-wire. The compass is about 3

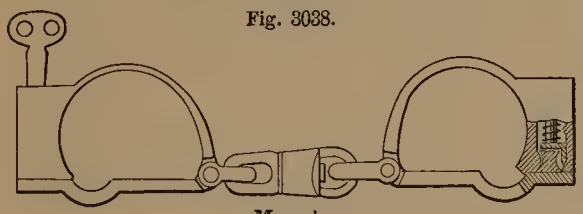
Fig. 3037.



Malting-Apparatus.

octaves. The strings are put in vibration by a plectrum held in the left hand. See *Mandola*, Bonanni, *Istromenti Armonici*, Roma, 1776; plate LV.

Fig. 3038.



Manacles.

Man'dore. (*Music.*) A four-stringed lute.

Man'drel. 1. (*Lathe.*) Often incorrectly spelt mandril, which unfortunately is a short-tailed baboon with a red and blue face. The *cynoccphalus*. *a*. An arbor or axis on which work is temporarily placed to

Fig 3039.

Adjustable Mandrel.

be turned. The arbor which revolves in the head-stock of a lathe and carries the upper pulley, and also the chuck or face-plate, if one be used. The example is an adjustable mandrel, having keys which fit in inclined longitudinal seats in the mandrel, and which are adjustable therein by a screw-sleeve on the shank.

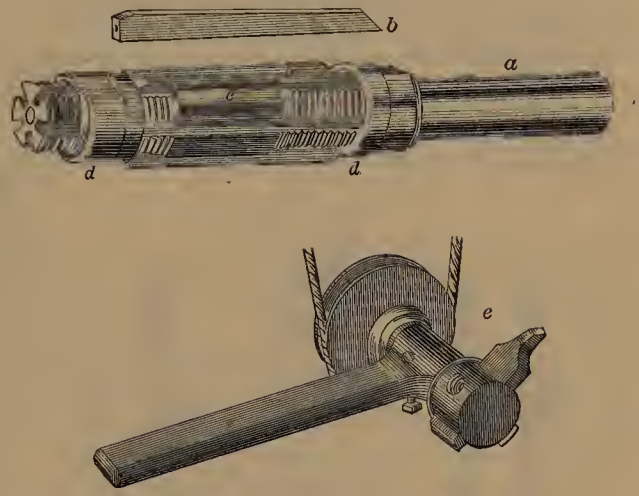
Traversing mandrels *e* are used in connection with a lathe, and are driven by gearing from a countershaft overhead. The one illustrated may be screwed into the tool-post of the slide-rest, and the belt from the countershaft carried on the small pulley, which runs at 1,500 revolutions per minute.

The use of the tool is to make ornamental designs or circular carving on all kinds of turned work.

2. (*Boring.*) The arbor *a* of Critchley's expanding mandrel for reaming has five grooves fitted with keys, cutters, or expanding tools *b*, according to the nature of the work or the office of the tool.

A screw-thread is cut on the body of the mandrel, and a portion of it is left in the center, as at *c*, to

Fig. 3040.



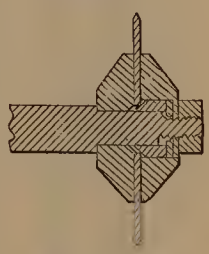
Expanding Reamer and Traversing Mandrel.

strengthen and prevent springing. The cutters are beveled at each end and confined in their places by nuts *d*, so that it is only necessary to slacken them off and slide the cutters down in the tapered grooves to expand or counteract their outside diameters, and thus adapt them to various dimensions of work.

3. The revolving spindle of a circular saw or a circular cutter.

As the annular bush slips upon the mandrel, its conical face penetrates the central orifice in the saw, and maintains the concentricity thereof; an elastic packing intervenes between the bush and the end collar.

Fig. 3041.



Saw-Mandrel.

4. (*Forging.*) A round rod of any desired diameter, used in giving an interior cylindrical form to a forging, as a *nut* or hollow spindle.

5. (*Casting.*) A plug around which a body of metal or glass is cast.

Man'drel-lathe. A lathe adapted for turning hollow work, which is clasped by a chuck on the end of the mandrel in the head-stock; or for turning long work which is supported by the head and tail centers. It is the usual form of well-made lathes for metal and wood turning. See LATHE.

Man-en'gine. A mechanical lift for raising and lowering men in the shafts of mines. The same device is used in factories, and in some hotels.

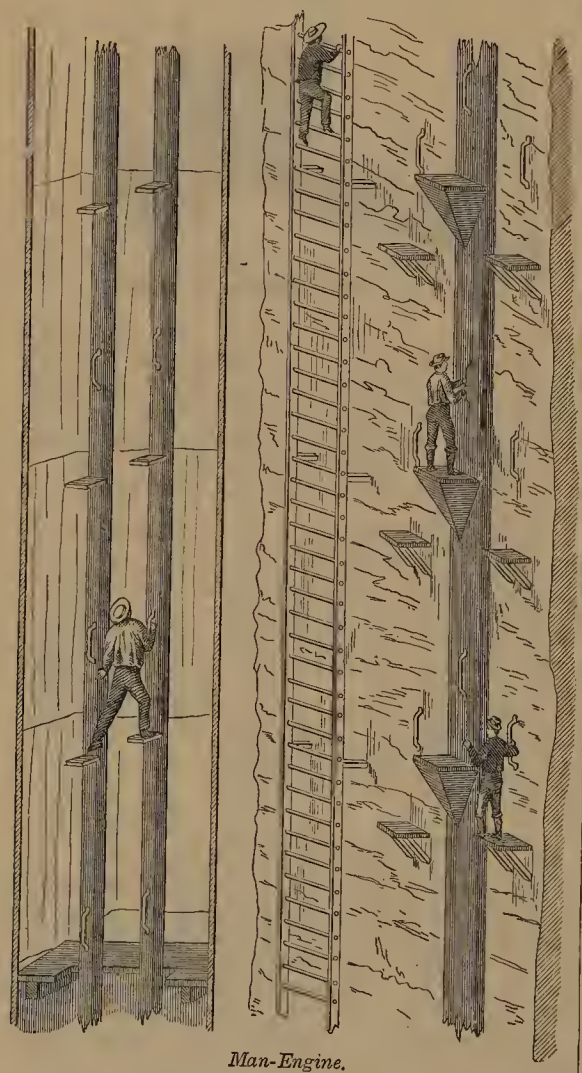
The modes of construction vary; the most secure is an application of the screw or the piston; the most rapid, a platform raised by rope and drum. (See CAGE; WATER-ENGINE; ELEVATOR.) One of the simplest is the reciprocating vertical rod with platforms at intervals.

The latter form is specifically known as the man-engine, and was invented in the early part of the present century by Bergmaster Dörrell of Clausthal, in the Upper Hartz, who used two pump-rods, which, side by side, went up and down a shaft, and fixed to them small platforms and handles at all those points of the rods which came opposite after every stroke. So, by

simply changing his stand after each stroke, from one rod to the other, a man would be lifted up to the surface. The plan was adopted in Germany, Belgium, France, England, but the "engine" was driven by special machinery, that at the deep silver-lead mines of Przibram in Bohemia having, since 1854, a steam-engine with two cylinders and cataract gear. The man-engine reaches a depth of 2,400 feet, and 3,000 men go up and down it daily, in three shifts of 8 hours each. It has a stroke of 10 feet. A similar engine at another shaft in the same mine has a stroke of 12 feet.

At the Trevesan mine in Cornwall, which is 300 fathoms deep, a man-engine has been constructed for lifting the miners and lowering them to their

Fig. 3042.



Man-Engine.

work, a depth of 240 fathoms. It has two parallel vertical rods, which are provided with stages or platforms and are reciprocated past each other. The stages are 2 fathoms apart, and each rod receives a motion through the same distance.

A man stepping on to the lower platform, say No. 1 of the left-hand rod, is raised by the lifting of the rod which brings him to the level of platform No. 2 on the other rod, which is at its lowest position; on to this he steps. When platform No. 2 rises he reaches the level of platform No. 3 on the opposite rod, and so he keeps stepping from one side to the other, rising 12 feet between each step. The platforms are opposite to each other at the dead points of the engine-crank, and thus pause for a slight space of time while the miners step off one and on to the other. A string of men thus ascend with merely the labor of stepping from one platform to another. The descent is the converse operation, in such case the man stepping on to the platform which is about to descend.

In a modified form, one set of steps is on the vertically reciprocating rod and the other set fixed on the side of the shaft. This plan is only half as fast as the other, the miner pausing half his time and ascending at intervals.

In the "Devon Great Consols" mine, England, the shaft of 1,020 feet depth has landings at intervals of 12 feet, and openings through which the timber rod of 8 inches square descends, having on it steps 18×15 inches, the openings in the landings being 27×24 inches. See left portion of Fig. 3042.

The men in ascending occupy one side of the landings, whilst those descending use the opposite side, which obviates any confusion in stepping on and off. It is evident that as the stroke of the engine is 12 feet, and as it makes five strokes per minute, a man descends at the rate of 60 feet per minute, and therefore takes 1,020 seconds to descend 170 fathoms; and if 100 men require to descend to that depth, the hundredth man will necessarily be 1,188 seconds behind the first, and the time requisite for the whole will be $1,188 + 1,020 = 2,208$ seconds, or 36.8 minutes. Thus, when the engine is working full, each step in rising carries a man and in descending carries a man, a man landing on one side of the platform and giving place to a man on the other side who steps on to descend, as the shifts of men pass each other in the shaft.

Man'ga-nese'. Equivalent, 27.6; symbol, *Mn.*; specific gravity, 8; fuses at the same heat as wrought-iron. It is a grayish-white, brittle, hard metal, resembling cast-iron. It is used in arts and manufactures in several ways.

It is the *glass-maker's soap*, used to correct the green color of glass, which is owing to the presence of protoxide of iron, converting it into the comparatively colorless peroxide.

It is also used in the Bessemer and similar processes, to decompose the oxide of iron. *Spiegeleisen*, which contains a notable quantity of manganese, is used for this purpose where conveniently attainable. See BESSEMER PROCESS, p. 277.

Man'ger. 1. (*Shipwrighting.*) A space abaft the *hawse-holes* on the working-deck, bounded by planks lying athwartships, and serving to prevent the water that comes in at the *hawse-holes* from flooding the rest of the deck.

2. (*Husbandry, etc.*) A feeding-trough for grain; usually accompanied by a rack for hay.

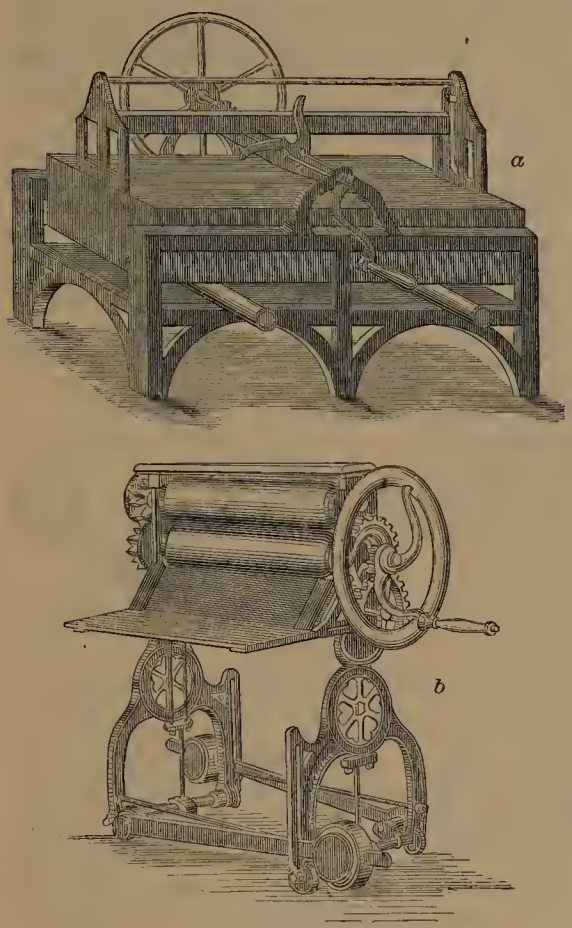
Man'gle. A machine in which damp clothes are smoothed by roller pressure. *a* represents the old-fashioned mangle, which had a box weighted with stones and reciprocating upon rollers which ran back and forth upon the clothes, spread upon a polished table beneath.

b is an improved form of mangle on the principle of the wringer. The clothes are passed between pressure-rollers driven by gearing.

In Fig. 3044, a series of rollers is disposed around a central drum, so that the garments are not subjected to undue pressure at but one or two points, as in the case of mangles having only two rollers.

On the frame axis of the large roller is an open wheel gearing into pinions on the axes of the smaller rollers; each of the latter has a rubber spring which

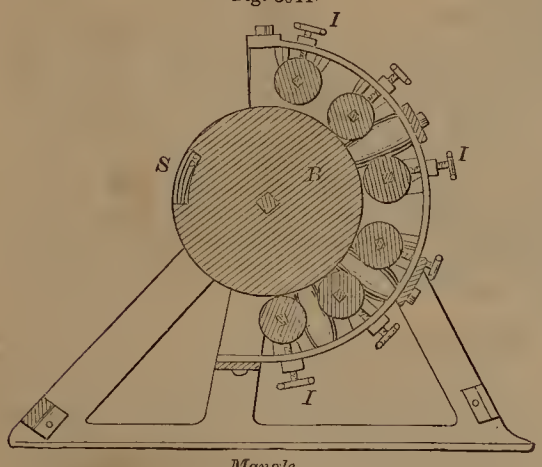
Fig. 3043.



Mangles.

presses it towards the large roller, and the pressure of the spring is regulated by a thumb-screw *I*. The large revolving roller has a clamp *S* for the edge of the clothes as they are fed between that roller and the series of rollers that abut upon it. This is to prevent the necessity of feeding the clothes at the

Fig. 3044.



Mangle.

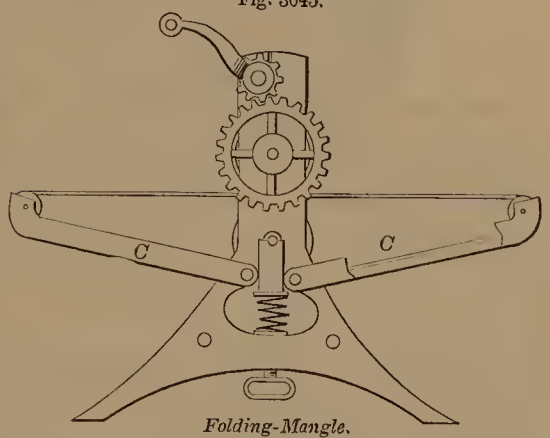
throat between the roller *B* and the first small roller.

The improved mangle for smoothing and stretching woven goods previous to starching and calendering, has a number of rollers fixed in a strong frame, and capable of being forced together by levers or screws. In some mangles, the bottom rollers have grooves diverging from the center, so as to spread the cloth outwardly towards each edge as it passes through, removing the creases. The cloth is fed to the mangle floating on the surface of water in a cistern.

Starch is applied in a somewhat similar machine, the cloth passing over a roller which dips into a starch trough, and the rollers arresting the superfluous portion as the cloth passes between them.

Fig. 3045 is a mangle in which the clothes spread upon an endless apron are passed between a pair of

Fig. 3045.



Folding-Mangle.

rollers, the upper one of which is driven and the lower one supported by springs to permit a yielding pressure. When not in use, the side pieces *C C* fold up against the standard for compact stowage.

Man'gle-rack. (*Machinery.*) A rack having teeth on opposite sides, engaged by a pinion which meshes with the opposite sides alternately. Thus the continuous rotary motion of the pinion is converted into a reciprocating motion, as in some forms of the mangle. See MANGLE-WHEEL.

Mang'ler. A machine for grinding meat, to render it more easy to masticate or to stew. A *meat-mangler*, a *masticator*.

Man'gle-wheel. This is used in mangles for pressing clothes, the object being to obtain a reciprocating, rectilinear motion of the weighted box, by means of a continuous rotary motion of the driving-pinion, to whose shaft the hand-crank is attached. As the pinion is rotated, it passes from the inside to the outside teeth of the wheel alternately, giving a reciprocating rotary motion to the wheel, which communicates a reciprocating rectilinear motion to the box. The shaft of the pinion traverses a groove in the wheel as the pinion passes from one side of the rack to the other. The pinion-shaft has a vertical movement in a straight slot in the outside bar as it makes the change from its upper to its lower position, and *vice versa*.

Fig 3046.

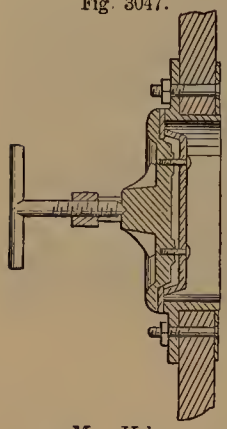
Mangle-Wheel.

Man'heim-gold. A brass used by jewelers, as an imitation of gold. Copper, 3 ; zinc, 1 ; tin, a small quantity. See also SEMILOR ; ALLOYS, JEWELERS', p. 63.

Man-hole. A hole in a cesspool, drain, iron boiler, tank, or a chamber or compartment on an iron ship, designed to allow the entrance of a man for examination, cleansing, and repairs.

In boilers and tanks it is usually secured by a bridge and bolt, so as to render it water, steam, or

Fig. 3047.



Man-Hole.

air tight, as the case may be. In drains, the cover is a lid with a stink-trap joint.

Man-hole Door. The cover or lid of a man-hole in a boiler or tank. A *man-hole plate.*

Man'i-chord. (*Music.*) An instrument resembling the SPINET and HARPSICHORD (which see).

It was originally a monochord (*single string*), and is referred to by Giraud de Calanson, a poet of Provence (*manicorda, ab una corda*).

It was played by *quills*, operated by *jacks* and *keys* on a *key-board.*

It was one of the predecessors of the piano-forte. See PIANO-FORTE.

Man'i-fold Writ'er. A device by which a number of copies may be written at once, the pressure of the stylus being communicated through a number of leaves of thin paper, between each of which is a greasy sheet of colored paper that imparts its color to the page with which it is in contact.

It was patented by Wedgwood in England in 1806. It has been much used by correspondents of the press, who thus write a number of letters to the various papers for which they cater.

Man'i-kin. An artificial figure representing the human body, and capable of being dissected to show the relative position and proportions of the parts of the body it is designed to illustrate. It is frequently of *papier-maché*, the detachable pieces being painted in imitation of the viscera and other organs.

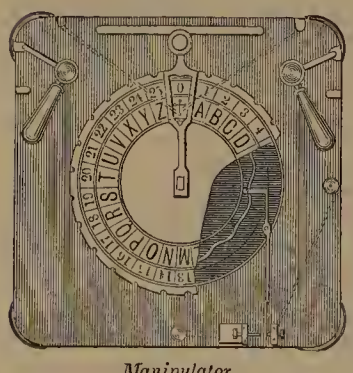
A manikin in illustration of obstetric subjects has an elastic perineum, uterus, and fetal head, so that the artificial parts may simulate the natural action of parturition.

Ma-nil'la-pa'per. Made from the fiber of a species of banana which grows in some of the East India islands. It is whiter than hemp, and the product is a stout, serviceable article. The fiber also forms cordage, sometimes known as *white rope.*

Ma-nil'la-rope. Rope made principally in the Philippine Islands, of the fibers of a species of banana.

Ma-nip'u-la-tor. The transmitting instrument attached to the dial telegraph.

Fig 3048.



Manipulator.

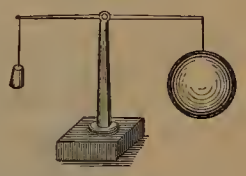
Fig. 3048, Bregnet's, has a dial corresponding to that of the receiving instrument, and an arm which is turned by a handle. The periphery of the dial has a notch at each letter, into which a pin attached to the handle falls to close the circuit. This is effected by an undulate wheel within the case, which turns with the handle, alternately causing a pivoted lever to make connection with the battery and with the earth.

Man-of-war. (*Nautical.*) An armed national vessel. A *line-of-battle* ship is one of the larger classes, so as to take its place in line of battle.

Ma-nom'e-ter. An instrument for measuring the elastic force of gases or steam. It consists of a graduated tube in which a body of confined air is compressed by the gas or steam under experimental test, a body of mercury intervening between the air in the tube and the gas or steam whose elastic force is to be ascertained. The tube containing the confined air, of a certain volume at a given temperature, is maintained at the said temperature by a bath, and is tested for the graduation of the tube by means of a column of mercury. It is then ready for the connection by a tube with the reservoir or boiler which contains the gas or steam whose elastic force is to be ascertained. A *steam-gage.* See also list under CALCULATING AND MEASURING INSTRUMENTS.

Boyle's statical manometer consists of a bubble of thin glass, about the size of an orange, which, being counterpoised in an accurate pair of scales, rises and sinks with the alternations of the atmosphere. This instrument only proved a change of density, but did not detect the cause, whether arising from a change in its own weight or its temperature, or both.

Fig. 3049.



Boyle's Statical Manometer.

Ramsden's manometer, used in the Arctic researches, had a tube of small bore with a ball at the end; the barometer being sp. grav. 2.97, a small quantity of mercury was placed in the tube to prevent communication between the external air and that contained in the ball, and that part of the tube below the mercury. A scale is placed on the side of the tube, which marks the degrees of dilatation arising from the increase of heat in this state of the weight of the air, and has the same graduation as that of Fahrenheit's thermometer, the point of freezing being marked 32°. In this state it performs the duty of a thermometer; but if the air become lighter, the bubble inclosed in the ball, being less compressed, will become dilated and take up a space as much larger as the compressing force is less; therefore the changes arising from the increase of heat will be proportionally larger, and the instrument will show the differences in the density of the air arising from the changes in its weight and heat.

Ramsden found that a heat equal to that of boiling water increased the bulk of the air from what it was at the freezing-point by $\frac{414}{1000}$ of the whole. The tube being graduated for heat, under a given barometric condition, the actual indications are compared with those of a thermometer, and the difference is what is due to barometric variation from the condition at which the instrument is adjusted. Thus, the manometer and thermometer readings being given, that of the barometer may be calculated.

Man'o-scope. An instrument for exhibiting the elastic force of gases or steam. See MANOMETER.

Man-pow'er. A *man* travels, without a load, on level ground, during $8\frac{1}{2}$ hours a day, at the rate of 3.7 miles an hour, or $31\frac{1}{4}$ miles in a day. He can carry 111 pounds 11 miles in a day. A porter going short distances and returning unloaded carries 135 pounds 7 miles a day. He can transport in a wheelbarrow 150 pounds 10 miles a day.

The maximum power of a strong man, exerted for $2\frac{1}{2}$ minutes, may be stated at 18,000 pounds raised 1 foot in a minute. — *Mr. Field's Experiments*, 1838.

A man of ordinary strength exerts a force of 30 pounds for 10 hours a day, with a velocity of $2\frac{1}{2}$ feet

in a second = 4,500 pounds raised 1 foot in a minute = *one fifth* of the work of a horse.

Man-rope. (*Nautical.*) A rope which forms a substitute for hand-railing at gangways, hatchways, etc. A *ladder-rope.*

Man-ropes are also used at the bowsprit, known as *bowsprit-horses.*

Man'sard-roof. Sometimes called the *French* or *curb* roof. First designed by a celebrated French architect, François Mansard, who was born in Paris in 1598. He designed many of the public buildings in the reign of Louis Quatorze.

It was invented to make the attics available for rooms, in consequence of a municipal law limiting the hight of front walls in Paris. It is also known as a *hip*-roof. See CURB-ROOF.

Man'tel. The ornamental facing and shelf around a fireplace; hence the terms *mantel-shelf, mantel-piece, mantel-tree.* See FIREPLACE.

Man-te-let'. 1. A movable blind constructed of planks, and sometimes plated, to cover a body of pioneers and protect them from small shot. A *sap-roller* is now used.

2. A protection of woven rope, etc., to protect gunners at embrasures.

Man'tel-piece. A beam across the opening of a fireplace, serving as a lintel to support the chimney-breast, or a *mantel-piece.*

Man'tel-shelf. A shelf above the facing of a fireplace. See FIREPLACE.

Man'tel-tree. The lintel of a fireplace.

Man'tle. 1. (*Founding.*) A covering of clay designed to form a matrix or mold for casting; as,

A porous clay covering of a basso-rilievo design in wax. The *mantle* and pattern are baked, the wax runs off, and the porous clay is a mold from which a casting is obtained in relief.

2. (*Building.*) *a.* The outer covering of a wall, of different material from its inner portion.

b. The enveloping masonry of a BLAST-FURNACE (which see).

3. (*Hydraulic Engineering.*) An inclosed chute which leads the water from a fore-bay to a water-wheel.

4. A cloak or wrapper.

Man'tlet. (*Fortification.*) A bullet-proof shield which is suspended in an embrasure to protect the gunners, or used as a movable shield to protect sappers in the trenches. See MANTELET.

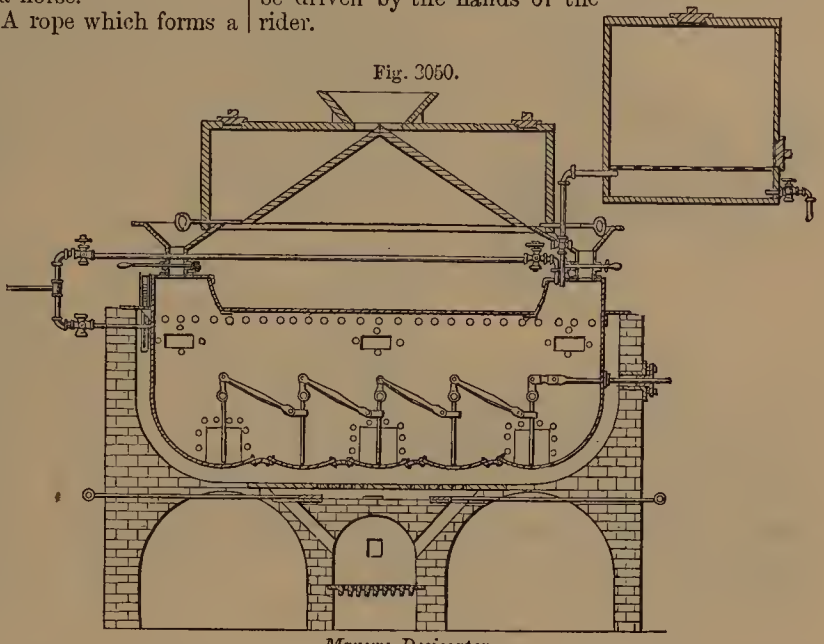
Man-trap. A trap for catching trespassers. It usually has two jaws, like a spring rat-trap, and those with smooth or toothless jaws are known as *humane* man-traps. It is not an American institution, either indigenous or imported.

Man'u-al. (*Music.*) The key-board of an organ, adapted to be operated by the hand, in contradistinction to the pedals, which are operated by the feet of the organist.

Man'u-al-key. An organ-key in the *manual,* played by the *hands;* the *pedal* keys are played by the feet.

Man'u-mo-tor. A wheeled carriage adapted to be driven by the hands of the rider.

Fig. 3050.

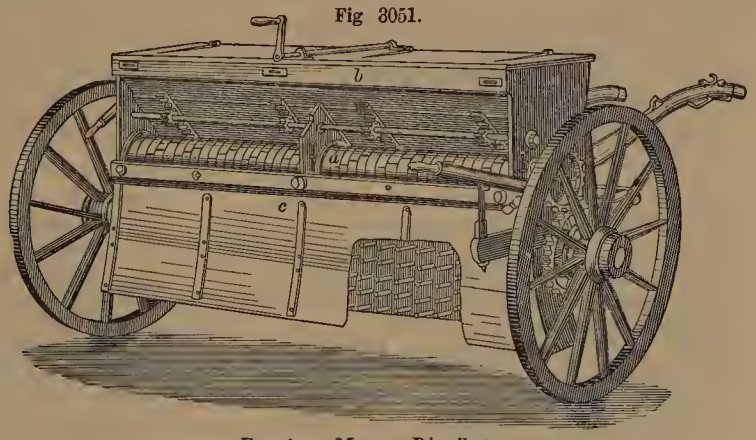


Manure-Desiccator.

Ma-nure'-des'ic-ca'tor. A furnace set within a brick chamber over which is an air-tight vessel forming a desiccating and mixing pan. Surmounting the mixing-pan is a hopper fitted with sloping bottoms provided with valves. Connected with the mixing-pan by a tube is a box provided with a false bottom, charged with some suitable absorbent, and into which the unabsorbed gases are conducted. Air is caused to circulate in the pan by means of an air-pump. The materials are stirred by oscillating paddles operated by a reciprocating rod passing through a stuffing-box.

Ma-nure'-dis-trib'u-tor. A machine (Fig. 3051) having a cylinder *a*, consisting of a series of rings with projecting surfaces, to which the manure is delivered from the box *b*. A series of scrapers below

Fig 3051.

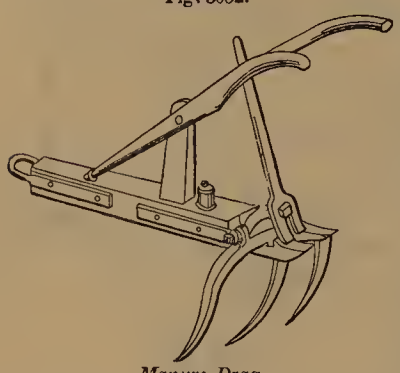


Broadcast Manure-Distributor.

the box is arranged with springs which admit of adjustment to exert a graduated pressure on the rings, according to the quality of the manure used. The containing box *b* is provided with a stirrer, and rows of pins in the delivery-barrel *c* cause an equal distribution of the manure as it falls to the ground.

Ma-nure'-drag. (*Agriculture.*) An implement drawn by a horse, and having teeth which catch into a bunch of manure, and drag it to a place where it

Fig. 3052.



Manure-Drag.

may be loaded or piled; on reaching the place the teeth are disengaged and the load dumped. Also used to scatter over the surface of a field manure which has been dumped in heaps.

Ma-nure'-drill. 1. An attachment to a grain-drill which deposits powdered fertilizer in the seed-row or broadcast, as it may be arranged.

2. A form of watering-cart to distribute in streams over the surface of a field the liquid carried in the box of the vehicle.

Ma-nure'-fork. A four-pronged fork for pitching manure, clearing stables, etc. The three-pronged dung-fork is mentioned by the Greek authors.

Ma-nure'-hook. A hand implement having three or four teeth bent at an angle with the handle, and used in dragging manure out of a stable, out of a wagon, or scattering manure-heaps in the field.

Ma-nure'-load'er. A form of horse-fork for loading into a wagon large bunches of stable manure.

Map. A representation of a portion of the earth's surface on a plane. This portion, except when Mercator's projection is used, cannot be greater than a hemisphere. There are several methods, known as "projections," employed in map-making for laying off the parallels and meridians, and locating the various positions of geographical points so as to, as far as possible, avoid relative distortion and exhibit a true likeness of the territory which the map is intended to embrace.

Anaximander of Miletus, 570 B. C., is credited with the invention of charts and maps. This is improbable, as the necessities of the Egyptians in measuring and dividing their Nile-irrigated and artificially irrigated lands must have made land-surveying and plotting a principal mode of determining the allotment of taxes. The revenue was derived from the use of water during the overflow of the Nile, and afterward of that which was stored in reservoirs during high water, — the simplest form of taxation upon property; the eminent domain of water being vested in the sovereign. The Egyptians, says Eustathius, "recorded their marches in maps."

Plate XXIX. has a representation of the popular idea of the earth in the time of Homer, 900 B. C. It consisted of a strip of land around the Pontus Pelagus, and even the boundaries were not known toward the northwest. Cimmerian darkness brooded upon the deep which surrounded the land.

Next is the world as known to Hecateus about 500 B. C., say about the time of Daniel. The borders of the Mediterranean are defined; the Iberi and Celtæ are known; the pillars of Hercules on the west and the Caspian on the east mark the longitudinal extent; back of Asia Minor is a greater Asia, which extends westward to the Nile.

In the world of Herodotus, the Caspian was changed from an indentation in the land to a lake. Asia extends to the Atlantic; Libya is a subdivision.

"Aristogoras, the tyrant of Miletus, showed to King Cleomenes of Sparta a bronze tablet, on which the whole circuit of the earth was engraved, with its seas and rivers." — HERODOTUS, V. 49.

In the geography of Democritus, 300 B. C., Europa, Asia, and Libya are acknowledged divisions.

In the maps cited by Herodotus and other geographers of his time, the grand division now known as Africa was called Libya. The term Europe is from a Semitic word *Ereb*, the *west, setting, darkness*, etc. Asia signifies the opposite, — the *east, rising*, etc. The origin of the term Libya is lost in obscurity. The same, except as to period, may be said of the Latin word Africa. Its derivation was a mystery 2,300 years ago.

"For my part I cannot conceive why three names, and women's names especially, should ever have been given to a tract which is in reality one, ... nor can I even say who gave the three tracts their names, or whence they took the epithets. According to the Greeks in general, Libya was so called after a certain Libya, a native woman, and Asia after the wife of Prometheus. The Lydians, however, put in a claim to the latter name, 'as being from Asius, the son of Cotys.' . . As for Europa, no one can say whether it is surrounded by the sea or not, neither is it known whence the name of Europa is derived, nor who gave it name, unless we say that Europa was so called after the Tyrian Europa, and before her time was nameless. . . However let us quit these matters. We shall ourselves continue to use the names which custom sanctions." — HEROD., IV. 45.

In former times the geographers were undecided where to draw the dividing line between Asia and Libya, as seen in the first four figures, Plate XXIX. The Egyptians were of known Asiatic origin, and it was considered more logical to include them in Asia. The eastern border of the land, abutting upon Libya, was for a time adopted. Afterwards the Tanais and the Nile were the limits of Asia, one half of Egypt being ascribed to Africa. Herodotus considered it absurd to divide the country of one people between two continents. Ptolemy, the geographer, defined the Red Sea and the Isthmus of Suez as the boundary between the continents.

Next is the map of the world according to Eratosthenes and Strabo. Eratosthenes (276–196 B. C.) of Alexandria was the discoverer of the obliquity of the ecliptic, and was the founder of geodesy. He determined the circumference of the earth by measuring a degree of the meridian. Measurements of an arc of the meridian have been made by the Chaldeans, by Eratosthenes, by Al Maimon, by Piré, and more lately by the French, English, Germans, and others; in Peru, Lapland, British India, and elsewhere. (See ARMIL; ARMILLARY-SPHERE; ASTRONOMICAL INSTRUMENTS; ODOMETER.) We regard Eratosthenes with profound respect as the author of the *science* of geography, and the name thereof. The extent of each zone he determined by the length of the solstitial day, and called them *climates*.

The "map of the world" by Hipparchus (150 B. C.) is founded on the discoveries of Eratosthenes, and is the first recorded attempt to assign geographical positions by longitudes and latitudes, obtained, the former from lunar eclipses, and the latter from lengths of the shadow measured by the gnomon.

In Strabo's time, about the Christian era, it was customary to draw a meridian and parallel for each important place whose position was considered as determined. Ptolemy, about A. D. 150, simplified the method, and probably introduced the regular plan of dividing the area by lines 5° or 10° apart, as the case might be. See cut, also "Ptolomæi Geographiæ," Roma, 1508. Congressional Library.

The maps of Eratosthenes and Ptolemy show a marked advance in geographical knowledge, especially in the bounds of Asia and Libya, the latter re-

PROGRESS OF MAPPING FROM 900 B. C. TO A. D. 1520.

PLATE XXIX. (2400 *Years.*)

See page 1333.

ceiving in the map of Ptolemy its new name of "Africa." The old belief in a circumscribing sea is evident in the upper map, where Libya is apparently extended merely to balance the newly discovered extent of Asia, the insular character towards the south being assumed, as in the earlier maps. In the map of Democritus, the Mesopotamian rivers flow into the ocean and mark the extent of geographic knowledge, in an eastern direction, of the Mediterranean nations. In the next map these rivers debouch into the Persian Gulf; and India with its marginal rivers, the Indus and the Ganges, forms an eastern extension. Taprobane (Ceylon) is also shown. Britannia and Ierne come upon the scene with the Cassiterides or Tin Islands, which had been known to the Phœnicians for 1,000 years. There is also an indication of a land across the Baltic. It should also be mentioned here that this map of Eratosthenes was merely a plane exemplification, and that he was fully aware of the spherical form of the earth. Aristotle had said, 100 years before, that it was possible that Spain and India were only separated by the sea. Eratosthenes said that only the extent of the Atlantic Ocean prevented sailing from Spain to India along the same parallel. In the map of Ptolemy, the land grows toward sunrise, Burmah with the peninsula of Malacca comes into view, with some traces of an eastern archipelago, and a country beyond India of unknown and undefined extent; so much land in this direction, indeed, that the sea is suppressed. Taprobane is still there, but the old geographer who put upon his map the interior lakes of Africa where Livingstone found them to be, would not take the sea for granted on the southern confines of Africa more than he would on the eastern regions of Asia. Africa assumes large proportions, and the name Libya becomes local; indeed, a dotted line uniting a hypothetical eastern land with a possible extension of Africa is suggested as the termination of salt water southwardly.

Dr. Livingstone's last letter, dated from Lake Bangweolo, December, 1872, and published April 28, 1874, finishes by saying: "If the good Lord gives me strength and influence to complete my task I shall not grudge my hunger and toil. Above all, if He permits me to put a stop to the enormous evils of this inland slave-trade I shall bless His name with all my heart. The Nile sources are valuable to me only as a means of enabling me to open my mouth among men. It is this power I hope to apply to remedy the enormous evil, and join my little, helping hands in the great revolution that in His all-embracing providence He has been carrying on for ages, and is now actually helping forward."

Next we recognize the map of Cosmas of Alexandria, known as *Indico-pleustes*. His map was made about A. D. 547, and was regarded as conclusive by the Fathers of the Church. So said the doctors of Salamanca, in 1486, to Columbus, who proposed to reach the east by sailing to the west. The geographer of the Church represented the earth as a plane twice as long as it was broad, embracing the Mediterranean and indented by the Red Sea, the Persian Gulf, and the Caspian; around it was the ocean. It most resembled the map of Homer's time, 1,400 years before, and was a ridiculous burlesque in a city where Ptolemy had lived but four centuries previously. But Cyril and the monks intervening had undone in a few years the progress of ten centuries. The square shape of the land was probably in deference to the Scripture expression, "the four corners of the earth." In another view of the earth as understood by Cosmas, a vast mountain rises beyond the "Great Sea" (the Mediterranean), and when the sun emerges from behind the mountain, it is day; when he retires behind it, it is night. The circles represent the Creator looking down, the sun orient, the sun occident. The pear-shaped place half-way up the mountain is the Garden of Eden.

To come down farther in order of time, we notice the representations of the eastern and western hemispheres, as depicted on the terrestrial globe of Martin Behaim, 1492. This may be taken as representing the state of geographic knowledge out of Salamanca and the cloisters. Africa had been circumnavigated by Vasco da Gama; Asia is driven over to the eastward as far as Marco Polo is deemed to have gone in his months of weary travel. So large a proportion of the circumference of the earth was held to be embraced by the circuit of Europe and Asia, that the latter about fills the western hemisphere, the goodliest island of "Cipango" (Japan) lying off the coast of the "far Cathay." In the mid-Atlantic is the island of Antilia, a spot partly conjectural, and also the island of St. Brandan, which was purely imaginary. Thus was the globe depicted before the sailing of Columbus, and his projected voyage was not expected to be much greater than the length of the Mediterranean. He sailed and discovered what he considered to be the "Island of Antilia" (Cuba). An island under that name had appeared on the charts since 1425. Columbus was for discovering a western route to India in the interest of the Spaniards, that they might share in the rich Oriental trade then almost monopolized by the Venetians. He supposed himself to have reached the outlying islands of the Asiatic coast, and tried to worm his way among them to reach China and India. The voyage was repeated with the same intention. His third voyage carries him to the Orinoco, and the volume of water encourages a hope that the gap is found. During the next year, 1499, Vasco da Gama anchors in the Tagus with trophies from Calcutta; the Portuguese have turned the Venetian position, and the trade is their own. The western essays have yet been fruitless, for no India has been reached, and the fourth voyage of Columbus, in 1502, in which he reaches Central America, is yet barren to him, for no strait is found. Columbus died in 1506, supposing that he had discovered India, though surprised at not being able to make connection with the eastern voyagers and the land of Marco Polo's adventures. In 1500 he asserted that, "if any one does not give him credit for having discovered the remaining parts of India," it must be from personal hostility. In 1502 he writes to Pope Alexander, "I discovered 1,400 islands and 333 leagues of the coast of Asia."

Above is a representation of the western hemisphere of John Schöner's globe of 1520, fourteen years after the death of Columbus, and, no doubt, published in good faith. In it the terra-borealis forms the only trace of the North American continent, and might answer for Newfoundland. Cuba and parts of the South American continent are plotted as islands of the eastern coast of Asia, adjacent to Java major, Java minor, and Zipango, which more immediately fringed the Asiatic coast. Cuba, the Antilia of Columbus, and yet the "Queen of the Antilles," lies north and south, parallel with the coveted island of Zipango (Japan), which so persistently eluded the search of the man of Genoa, who tried to push his caravel through a continent.

Sea-charts were brought to England, 1489, by Bartholomew Columbus, to illustrate his brother's views respecting a western continent. The first tolerably accurate map of England was made by George Lilly, who died 1559.

Gerard Mercator published his Atlas in 1556. In this, as in the modern maps on the "Mercator Projection," the meridians and parallels are straight lines and cut each other at right angles.

The distance between the parallels is increased with the latitude, so as to be proportionate to the actual distance of the meridians apart.

The principles on which this projection is founded were first explained by Edward Wright, an Englishman.

It is universally employed in nautical charts.

"My Lord Barkeley wanting some maps, and Sir W. Coventry recommending the six maps of England that are bound up for the pocket, I did offer them." — PEPYS'S *Diary*, 1667.

The great geographical achievements which distinguished the close of the fifteenth and the early portion of the sixteenth centuries, or the thirty years from 1492 to 1522, consist in the discovery of tropical America, the rapid determination of its form, the passage round the southern point of Africa to India, and the first circumnavigation of the globe.

The triangular form of Africa is distinctly laid down in the planisphere of Sanuto as early as 1306; in the Genoese Portulano della Medice Laurenziana of 1351, discovered by Count Baldelli; and in the map of the world by Fra Mauro. 1,700 years before this, Herodotus had characterized as incredible the statement "that those who sailed around Libya, in sailing from east to west, had the sun on their *right* hand," as in sailing eastwardly in the Mediterranean the sun at noon is always to the left. He farther states that Necho commanded the Phœnicians to make their return to Egypt by the pillars of Hercules. Strabo, while discrediting the accounts of circumnavigations previously said to have been accomplished, does not deny the possibility of the circumnavigation, but affirms that from the east to the west there was but little wanting to its completion.

Bartholomew Diaz reached and actually doubled the Cape of Good Hope in May, 1487, but, deterred by the storms, put back and reached Portugal in December of the same year, so that it was reserved for Vasco da Gama to first pass beyond the region of storms which surrounds the Cape and enter upon the waters, usually more placid, of the great Indian Ocean.

Humboldt says: "I have shown elsewhere how a knowledge of the period at which Vespucci was named 'Piloto Mayor' would alone be sufficient to refute the accusation first brought against him in 1533 by the astronomer Schöner of Nuremberg, of having astutely inserted the words 'Terra di Amerigo' in charts which he altered. The high esteem and respect which the Spanish court paid to the hydrographical and astronomical knowledge of Amerigo Vespucci are clearly manifested in the instructions which were given to him when, on the 22d of March, 1508, he was appointed 'Piloto Mayor.' But the name of 'Americi Terra' had been proposed for the new continent as early as 1507, by a person whose existence even was assuredly unknown to Vespucci, the geographer Waldseemüller (Martinus Hylacomylus) of Freiburg in the Brisgau, the director of a printing establishment at St Dié in Lorraine, in a small work entitled 'Cosmographiæ Introductio insuper quatuor Americi Vespucii Navigationes.' The map of the new continent drawn by Hylacomylus, and contained in this edition, presents the first instance of the name of 'America' in the editions of Ptolemy's Geography. It is a great error to regard the map of 1527, now in Weimar, obtained from the Ebner library at Nuremberg, and the map of 1529 of Diego Ribero, engraved by Güssfeld, as the oldest maps of the new continent. Vespucci had visited the coasts of South America in 1499 (a year after Columbus's third voyage), in the expedition of Alonso de Hojeda. He could not have had any motive in feigning a voyage in 1497, for he, as well as Columbus, was firmly persuaded until his death that his discoveries were a part of Eastern Asia. For more than 20 years after his death, which took place in 1512, and indeed until the calumnious statements of Schöner in the 'Opusculum Geographicum,' 1533, and of Servet in the Lyons edition of Ptolemy's Geography, in 1535, we find no trace of any accusation against the Florentine navigator. Columbus himself, a year before his death, speaks of Vespucci in terms of unqualified esteem; he calls him 'a very good man,' 'worthy of all confidence,' and 'always inclined to render me service.' The same good-will toward Vespucci is displayed by Fernando Colon, who wrote the Life of his father in 1535 in Seville, four years before his death, and who, with Juan Vespucci, a nephew of Amerigo's, was present at the astronomical junta of Badajoz, and at the proceedings respecting the possession of the Moluccas.

"The confusion of dates in the numerous versions of Amerigo's voyages is not to be attributed to him, as he did not himself publish any of these accounts; such mistakes and confusion of figures are, moreover, of very frequent occurrence in writings published in the sixteenth century."

The entire guiltlessness of the Florentine navigator, who never attempted to attach his name to the new continent, but the magniloquence of whose accounts unfortunately drew upon himself more of the attention of posterity than he deserved, is decisively shown by the fact that he was not even cited as a witness in the suit instituted by the fiscal authorities of Spain against the heirs of Columbus, from 1508 to 1527, with the object of withdrawing from them the rights and privileges which had been granted by the Crown to their father in 1492, in which it was to be decided what parts of the new continent were first seen by Columbus. In the course of this suit it was never pretended that he had preceded Columbus in the discovery of the continent. Amerigo died at Seville, February 22, 1512. In 1520 maps were extant, having in them the name of America, proposed by Hylacomylus in 1507.

Las Casas, in treating on the subject in an unpublished work, the "Historia General de las Indias," says that the statement that Amerigo sailed in the year 1497 appears to have been an error of the pen and not an intentional false statement, and adds that "the *foreign writers* call the country America. It ought to be Columba." Farther on he attributes intentional deceit to Amerigo, but considers it strange that Hernando Colon, who had had in his hands Amerigo's account of his travels, "remarked in them no deceit or injustice toward the Admiral."

Even Copernicus contributed to the erroneously obtained celebrity of Vespucci.

To Humboldt we are indebted for the graphic representations of complex natural phenomena by means of lines on maps, such as the isothermals, which unite places of equal mean temperature, hypsometric lines, which unite places of equal hight, etc.; or depicting, by circumscribing lines or by color, regions of equal average temperature or rainfall, population, mortality, illiteracy, wealth, race, etc. The following names are used for lines drawn upon maps to connect places of equal conditions, as follows: —

For an illustration, see Blodget's "Climatology of the United States," Philadelphia, 1857.

Isobarometric, having equal barometric pressure.
Isochcimal, having same winter temperature.
Isoclinal, indicating equal magnetic dip.

Isocrymal, having same extreme of cold.
Isodynamic, having same magnetic intensity.
Isogeothermal, passing through points beneath the surface which have the same average heat.
Isogonic, indicating equal variation of compass.
Isohyetose, having same mean annual rainfall.
Isotheral, of equal summer temperature.
Isothermal, having same mean annual temperature.
Isotherombrose, where the quantity of summer rain bears the same proportion to the annual rain.

The surveys from which the data for the construction of geographical maps on an accurate and comprehensive scale are derived embrace both geodetical and astronomical observations; the former to determine the relative positions of geographical points and their distances from each other, and the latter to fix their absolute position on the earth's surface and establish the true meridian.

The geodetical part of the work is accomplished by first measuring with extreme accuracy on the most level surface that can be selected a base line of convenient length. In extensive surveys, embracing, for instance, a whole country, this is from five to ten or more miles in length. This serves as the basis of a system of triangulation, the length of the sides of the triangles being gradually increased as they recede from the base, until they are made as long as the nature of the country or the possibility of seeing the signals erected at the various stations will admit of; this may be as much as 100 miles, or even more in mountainous countries. The area covered by these primary triangles is subdivided by smaller triangles termed secondary, and these again by a still smaller system of tertiary triangles. This work is performed with the theodolite, the size of the instruments employed being proportioned to the character of the work, from those having a circle of 2½ to 3 feet diameter for the main triangulation to those of 6 inches for the tertiary. The filling in or determination of subordinate points, the outlines of the shores of bays and other bodies of water, may be effected with instruments of an inferior class. The plane table is used for this purpose by the United States Coast Survey. The data are now transferred to paper. A scale for the map having been determined on, the projection of the lines of latitude and longitude is made, and the positions of the different points laid down on the paper with a scale and circular protractor. The topographical features of the ground, the relative levels as ascertained by leveling during the progress of the survey, and such other details as are considered advisable, are represented by a peculiar system of shading and by symbols. The map is then ready to be transferred to copper, from which any number of copies may be printed. But a very small portion of the globe comparatively has been surveyed with an accuracy even approaching that above described. Africa, Asia, with the exception of British India, South America, a large part of North America, and even a considerable portion of Europe, afford no better data for the construction of maps than detached astronomical observations at different points and rudely measured or even estimated tables of distances. Points along the sea-coast have, owing to the requirements of commerce, been generally tolerably well determined, but our knowledge of the interior geography of several of the vast continents referred to is based largely upon mere report.

Maps in relief were first produced in Germany some time in the last century. From them Haüy conceived the idea of relief-printing for the blind.

Map-hold'er. A frame for the display of maps or charts. In one form the maps are on an endless web of cloth, which is rolled off from one roller and on to another, the display being in the space between the two. A *ribbon map*.

In another form the maps are hung from separate rollers in the manner of window-shades; either is pulled down as may be desired and is re-wound by a spring.

Map-meas'ur-er. An instrument with a little wheel of known circumference, which is made to roll along a line and indicate its length, the number of revolutions being counted, and the fraction, if any, observed by reference to the pointer and graduated perimeter.

Fig. 3053.

Map-Measurer.

Mar'a-bout. A peculiar kind of silk, generally containing 3 threads, and made from the white Novi raw silk. It is dyed without discharging the gum.

Ma-ram'ba. A musical instrument of Central America, consisting of a series of calabashes of different sizes set in a frame and having the tops cut off. Pieces of parchment or membrane are stretched over the openings, and are tuned so as to produce, when beaten with an implement resembling a drum-stick, the notes of the diatonic or other musical scale.

Mar'ble. 1. A granular and crystalline carbonate of lime. In sculpture the term is applied to several varieties of stone capable of receiving a high polish.

Statuary marble is known as saccharine limestone, having a texture resembling loaf-sugar. It belongs to the metamorphic rocks; and is non-fossiliferous, having been changed by heat.

Among the ancients the Pentelican and Parian marbles, the former a pure white and the latter having a creamy or waxy tint, were most valued for statuary purposes.

In modern times the best is derived from the quarries of Carrara.

The *Potomac marble*, so called, of which the pillars of the old House of Representatives, Washington, are formed, is a *pudding-stone* or *conglomerate*. It may be described as a gravel bound together by cement.

Alabaster is no marble, but is a species of gypsum. It is a *sulphate* and not a *carbonate* of lime.

There are many fancy varieties of marble used by marble-workers; these have names derived from the geographical position of the quarries, the color, markings, geological position, etc.

White marble has a specific gravity, 2.706; weight of a cubic foot, 169 pounds; weight of a bar 1 foot long and 1 inch square, 1.17 pounds; cohesive force of a square inch, 1,811 pounds; extensibility, $\frac{1}{1394}$ of its length; is crushed by a force of 6,060 pounds upon a square inch (Rennie).

Marble for tombstones, mantels, and generally where thin pieces are required, is divided by the saw. This is a plain, narrow plate of steel, and effects the division of the stone by attrition, being constantly supplied with sand and water.

After being sawn into slabs, its surface is ground down by a flat, coarse sandstone with water, or with an iron plate fed with fine sand and water, until all the marks of the saw are removed.

It is then rubbed with a fine sandstone and water, removing the marks left by the first operation. A still finer sandstone, pumice-stone with water and snakestone are then successively employed.

The final polish is given by means of rollers of woolen cloth or list, about three inches in diameter, charged with moistened flour of emery, which is worked uniformly over every part of the surface, and

subsequently by a similar roller with putty-powder and water. Sometimes an old cotton stocking is used instead of the roller, and in some delicate works crocus is employed intermediately between the emery and putty-powder. The marble must be washed after each operation, to remove every particle of the polishing material, which would otherwise scratch the work. Turned works are similarly polished, using two or three thicknesses of cloth, held in the hand, instead of the roll. Other kinds of work, as statuary and hard varieties of marble, require a somewhat different treatment.

Rough marble is in the shape of blocks from the quarries.

Rough-hewn marble is cut with the saw or squared with the stone axe.

Outlined marble is blocked out in the rough for an architectural ornament or sculpture by the *double-point* or the chisel.

Pierced marble is worked to bring out the ornaments in relief.

Polished marble is that which has been worked by a succession of materials of gradually increasing fineness. See MARBLE-POLISHING.

Finished marble is that which is ready for its place.

2. A plate of stone used by painters. A slab on which substances are levigated by a *muller*.

3. A stone or iron plate on which glass is rolled to shape it. A *marver*.

4. A printer's imposing-stone.

5. A style of coloring, for paper and book edges. See MARBLE-PAPER.

6. Playing-marbles are made of clay, calcareous stone, marble, agate, etc. Some of stone were discovered at Pompeii.

Playing-marbles were first introduced into England from Holland, about 1650. They are made in great quantities in Germany, and constitute a not unimportant article of trade. The stone is broken into fragments, which are sorted into sizes proportioned to that of the marbles to be made. These are then ground between a lower and stationary and an upper revolving millstone to remove asperities. They are next roughly rounded by friction against each other and against two cylinders of hard stone, one of which is caused to rotate at the rate of 40 to 45 turns per minute.

The complete rounding of the marbles is effected in an oblong wooden cylinder or cask, having a double bottom, in which are one or more cylinders of hard stone. This is caused to revolve at the rate of 40 or 45 turns per minute. The dust formed during this operation is then removed and mixed with emery in pieces the size of a bean; by this the final rounding and polish are effected, in the apparatus just described.

A shining polish is obtained by revolving the marbles in wooden cylinders with fine emery.

If they are to be colored, this is done previous to their receiving the final polish, by pouring the coloring material upon them in a liquid state. They are then polished by rotation in contact with a small quantity of calcined tin-dust.

By another process the pieces of stone are rounded between a lower turning millstone and an upper stationary wooden tray, each grooved to correspond to one half the marble. A stream of water is constantly poured through an aperture in the tray, which is arranged to descend as the volume of the mass diminishes by attrition, so as to exert a constant gentle pressure. The marbles are polished between two wooden trays similarly arranged.

Clay marbles are molded and baked.

Mar'ble, Ar-ti-fi'cial. An indurated composition of gypsum, alum, isinglass, and coloring materials incorporated into a paste and molded into form.

In Mellen's patent, 1872, any of the hydraulic or marble cements may be used. The cement is mixed with the colors, each color separately to a consistence which will admit of its being poured from a vessel having a spout.

The mixture is poured from the vessels in small streams upon a smooth surface of glass, wood, metal, or plaster of paris, so as to imitate the veins in any particular kind of marble, the interspaces being filled in with a mixture of cement and color corresponding to the color of the body of the stone. A wind-blast, produced by bellows or otherwise, is employed to make the colors flow, so as to produce the mottled appearance of marble.

For producing delicate veins, threads of silk or other material are dipped in the desired color and laid upon the smooth surface; these are drawn out after the cement has been poured on. The cement absorbs the color from the thread, exhibiting a fine streak of the desired appearance. After the various colors have been laid on the smooth surface, the back is smoothed over and strengthened by a backing of cement, pieces of metal being employed to bind the two together and impart firmness to the slab.

The process of Pichler of Vienna is recommended for plastic decorations of all kinds: Take one pound of good glue and boil it down so that it will be quite thick; add then half a pound of resin, or, better still, Venice turpentine, and mix well. Prepare a mixture of fine chalk and such mineral colors, finely pulverized, as are required for certain imitations. The less the ingredients are mixed, the better will be the imitation. The paste formed by blending the two mixtures is then kneaded until of the proper consistence. A few drops of oil may be added to it. This mass can be immediately used, and becomes hard like stone. If desired to be kept for a while, it is only necessary to wrap it in a moist cloth.

Mar'ble-cem'ent. A composition of gum-lac, colored to suit the occasion.

The rust cement is also used, composed of hydrochlorate of ammonia, 2; flour of sulphur, 1; iron filings, 16.

For coating insides of cisterns, pulverized baked bricks, 2; quicklime, 2; wood-ashes, 2; olive-oil to make a paste.

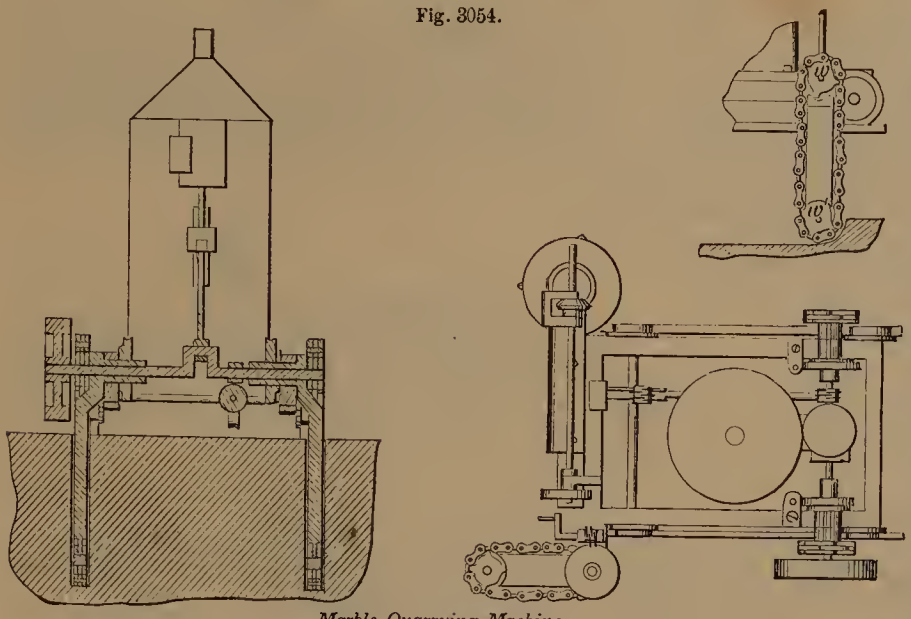
For stone seams and joints: pulverized tiles or hard brick, 6; white-lead, 1; litharge, 1; oil to compound.

Hydraulic cement, 12; triturated chalk, 6; fine sand, 6; infusorial earth, 1; all mixed with soluble soda glass.

Mar'ble-cut'ting Ma-chine'. A machine for cutting marble in the quarry. A *channeling* machine, which cuts deep grooves in parallel lines. This is sometimes done by the impact of a gang of stamping-chisels, but in the example is effected by a chain-saw whose links are armed with diamonds. The diamonds are held in the ends of split screw-bolts or clamps, which are tapered and forced into tapering cavities, causing them to contract upon the diamonds. The diamonds are applied on the edge of a rotating disk, or the links of an endless chain, and the supporting standard of the disk or chain is so connected to the driving mechanism that it may have feed in any direction.

The chain-saws are carried by wheels *w w'*, which are driven by shafting from the steam-engine on the truck, whose proper motion feeds the saws to their work. Devices are afforded for changing of the saws to vary the direction of cut. The lower right-hand figure shows the mode of presentation of the diamond-chain for making a horizontal under-cut.

Fig. 3054.



Marble-Quarrying Machine.

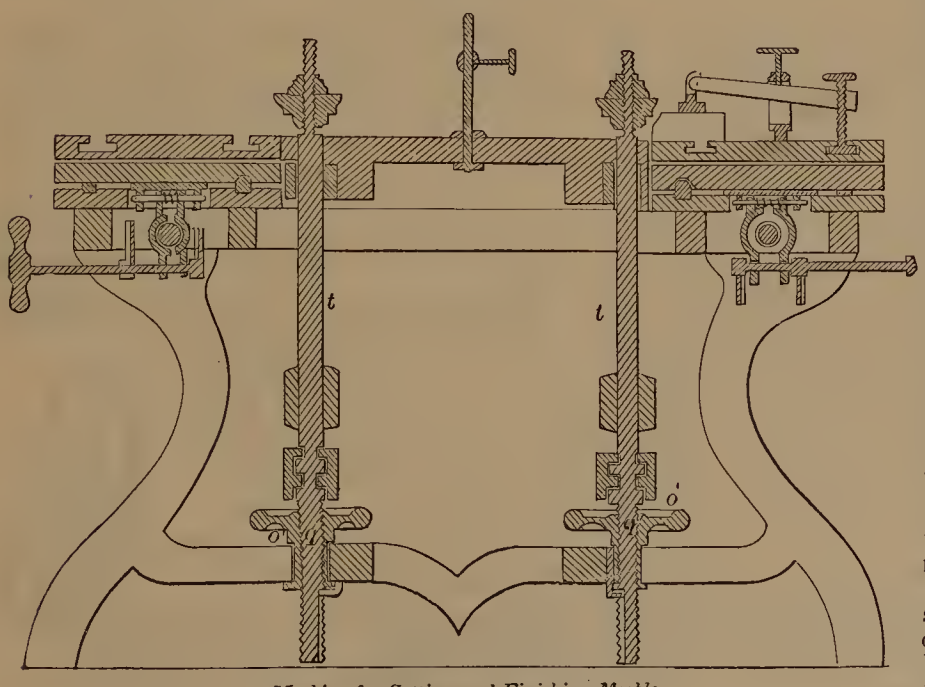
Mar'ble-edge. (*Bookbinding.*) A mode of ornamenting the edges of bound books. The process is described under MARBLE-PAPER (which see).

Mar'ble-fin'ish-ing Ma-chine'. One for truing and molding the edges of marble slabs for mantels, tables, etc. The molding-tools, having a contour the converse of the molding required, are keyed on the top of vertical, revolving mandrels *t t*, which are adjusted vertically by the hand-wheels *o' o'*, which traverse on the screws *q q*.

The feeding-tables at each side of the machine present the marble in the required line of motion to the revolving-tool. The cutting-tools are changed as the work progresses, some having perforations to supply abrading material.

The feeding-table is susceptible of two motions, one tangential to the circle described by the revolving-tool, and the other at right angles to that of the first.

Fig. 3055.



Machine for Cutting and Finishing Marble.

The right-hand table has a block clamped in position.

Mar'ble-grind'-ing Ma-chine'. A machine in which the rubber stone is reciprocated or rotated over the marble slab by mechanical means. In the example, the rubber is attached to the free end of the pitman by means of connecting-forks *i i* (Fig. 3056). Other machines operate upon a series of slabs laid in an annular trough, the rubbers having a combined rotary and revolving, or planetary motion. See STONE GRINDING AND POLISHING.

Mar'ble Hand-saw. A blade without teeth, and having a block handle at the back. It is used with sand for cutting slabs into pieces or slips.

Mar'ble-iz-ing Slate. Coloring its surface in imitation of variegated marble.

The slab is rubbed with pumice, and then polished with pulverized pumice and afterward with felt. It is then painted with the groundwork color, and its surface dipped in a vat containing water, on which oil-colors have been sprinkled, manipulated with a brush and subjected to a fanning process, in order to cause a variegated appearance.

Imitations of various kinds of marble are produced by an appropriate application of the different colors. Successive bakings and polishings complete the process.

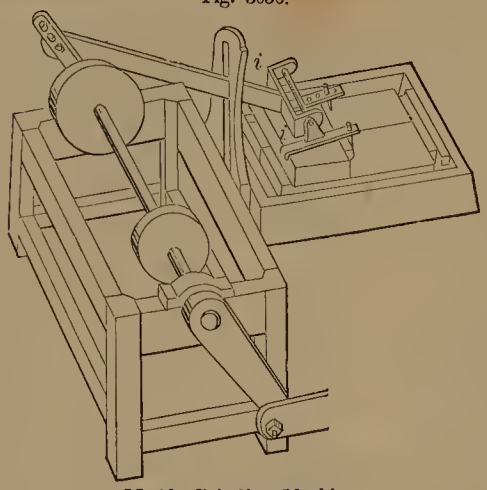
Mar'ble-pa'per. Paper ornamented with a colored pattern resembling marble; or ornamented by the same process with patterns bearing no analogy to those of marble, but assuming certain conventional forms, in which the colors are singularly blended and contrasted.

The process was invented in Germany about 1620, but was long maintained a secret.

The pulverized colors in a dry state are mixed with water and ground in a paint-mill, after which the chemicals used for giving them consistency are added, and the whole again passed through the mill.

Mineral colors only should be used, those of vegetable origin being apt to fade when exposed to the

Fig. 3056.



Marble-Grinding Machine.

light. For use, they are thinned with water and placed in wide-mouthed jars. The brushes ordinarily used for sprinkling the colors are small sash tools, the hairs of which are spread out into a circular form by driving a small nail with a leathern washer into the center of the handle.

A mucilage of gum, usually tragacanth or *gum-ogg*, is prepared, about the thickness of sweet-oil. This is placed in a trough, and the colors which are to form the pattern are sprinkled one at a time over its surface, those forming the veins first and that for the groundwork last. The paper, on a table to the left of the workman, is taken up, sheet by sheet, by the extreme corners, bent in the form of a bow, and gradually let fall on the composition in the trough. The colors, which float on the surface, and a portion of the mucilage, adhere to the paper, which is then taken up and hung on racks to drip, the color remaining and the mucilage falling into a trough below the rack.

The paper when dry is glazed by means of a piece of polished flint, semicircular in section, set in a block of wood, into the opposite side of which is inserted a pole 5 or 6 feet long, the upper end of which fits loosely in a groove in a spring-board above. The paper is laid on a grooved block, having a very smooth surface, secured to a strong wooden table; and the operator, using his right hand to propel the pole and his left to guide the paper, moves the flint-polisher back and forth over its surface, which operation, aided by the pressure of the spring-board on the end of the pole, effectually glazes the paper.

This primitive mode of glazing is now generally superseded by the process of calendering between two rollers of polished steel, which effects the result in a more perfect, durable, and rapid manner.

The edges of books may be marbled in a similar way. For this purpose a mucilage of linsced, allowed to simmer at a gentle heat for five or six hours, may be used instead of the more expensive gums.

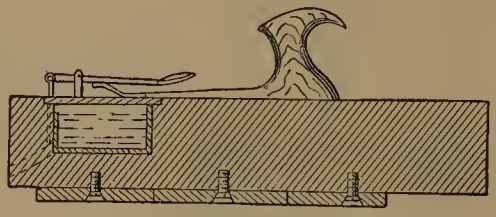
The varieties are thus cited by Cooley (Practical Recipes, page 753): *soap*, *thread*, *rice*, *tree*, *wax* marbling, according to the style of associating the colors, placing them on the mucilage, the use of combs, threads, etc., to dispose the colors, and the choice of materials.

Mar'ble-pol'ish-er. Marble is first rubbed with sandstone, and the beater, afterwards with pumice-stone. It is polished by hand with a linen cushion and emery-dust for colored marbles, and with the powder of calcined tin for white marbles, the emery being apt to redden them.

In Italy a piece of lead is used instead of linen.

A *rubbing-block* is used for carrying the grit or powder for grinding, surfacing, or polishing the faces of marble slabs. In the example, the polishing material of pulverized flint and gum-shellac is carried in a cistern in the rubber-block, and is allowed to es-

Fig. 3057.



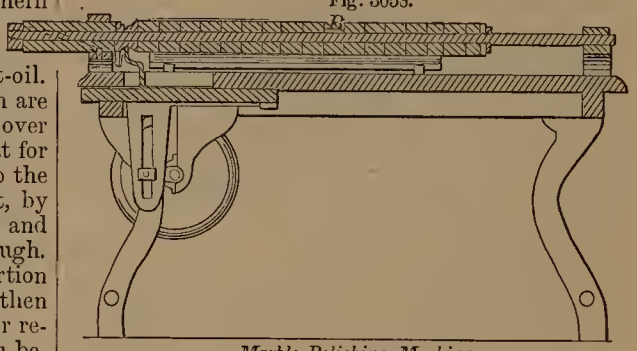
Marble-Rubber.

cape at a hole in front of the block when the gate is raised by touching the trigger.

In Maloy's patent, the marble slab is placed on the slide and its edge polished by an endless belt, which is tightened by an adjustable idler.

In this machine, Fig. 3058, the grinding-cylinder

Fig. 3058.



Marble-Polishing Machine.

B is made up of a number of collars slipped on to a mandrel. It is rotated and at the same time receives an endwise motion or a longitudinally reciprocating and intermittingly rotating motion above the table on which the slab of marble is placed.

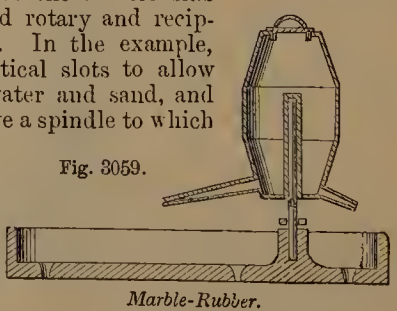
Mar'ble-re-lief' Work. One mode of making relief-work in marble is by painting the required ornament with varnish upon the surface of the marble, and then subjecting the exposed surface to acid. A mixture of hydrochloric and acetic acids has been used.

The varnish may be a solution of gum-lac in alcohol or the *ground* of the engraver, a resinous compound dissolved in turpentine.

This recipe is from the *Dictionnaire Encyclopédique*, 1785.

Mar'ble-rub'ber. A block or tray with a flat sole, moved above the marble slab with a combined rotary and reciprocating motion. In the example, the tray has vertical slots to allow the passage of water and sand, and a socket to receive a spindle to which the handle is attached, and which supports the water-vessel.

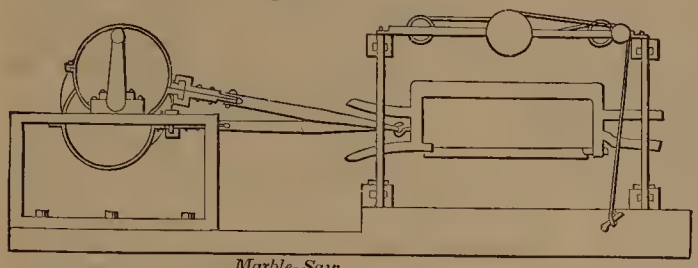
Fig. 3059.



Marble-Rubber.

Mar'ble-saw'ing Ma-chine'. A machine in which the saws are reciprocated by mechanical means. In

Fig. 3060.

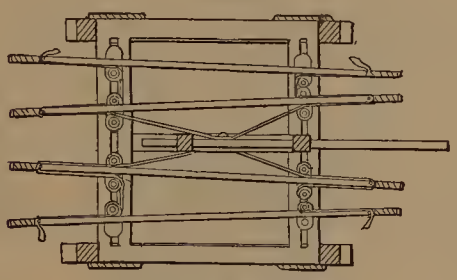


Marble-Saw.

the example (Fig. 3060) the saw is operated by pitmans and eccentrics.

Fig. 3061 is a plan view of a machine in which the saws may be adjusted to saw a block into pyramidal forms. Guide-blocks, provided with rollers over which the belts pass, are secured within

Fig. 3061.

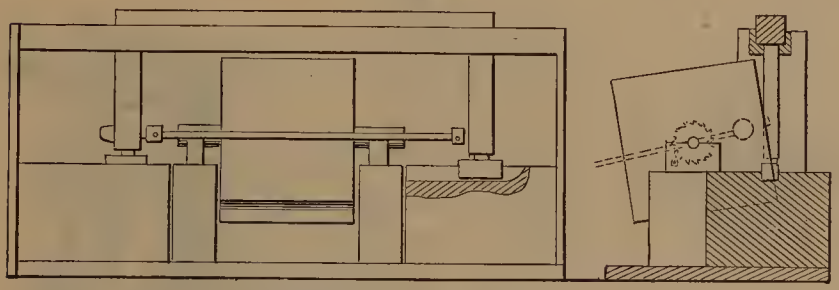


Marble-Sawing Machine.

slots on each side of the saw-frame, by which the saws are adjusted to operate at various angles and at different distances from each other.

Fig. 3062 is a machine in which the block is adjusted on centers and rotated against the saw, so as to cut the block into a cylinder or a conical frus-

Fig. 3062.

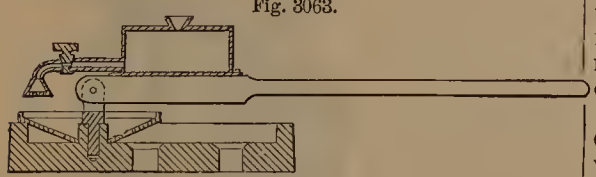


Marble-Saw for Curved Forms.

tum. The rod or wire saw has a triangular cross-section.

Mar'ble-scour'er. A rubber for surfacing marble slabs. The metallic block has a handle by which it is moved backward and forward over the marble

Fig. 3063.



Marble-Scourer.

floor to be scoured. Sand is carried in the recessed top, which has holes communicating with the lower face. A box on the handle contains water, which is supplied to the working-face through a faucet and rose nozzle.

Mar'ble-work'er's Files. The files and rasps (*m n o p*, Fig. 3032) of the marble-worker and sculptor are of various shapes and grades of fineness. Hiram Powers's *perforated file* has holes to allow the escape of the dust. See STONE-CUTTER'S TOOLS.

Mar'bling. In the ordinary method of marbling book-edges, a trough about two inches deep is filled with a solution of gum-senegal water. Various coloring matters, ground in spirits of wine and mixed with a small quantity of ox-gall, are thrown upon the surface of the water and disposed in the pattern desired by means of a quill and comb. The book is now tied between two boards, and the edges being dipped into the trough the colors become attached; the workman blows away the excess of gum and allows the colors to dry. They are afterward burnished. See MARBLE-PAPER.

March. (*Weaving.*) One of the short laths laid across the treadles under the shafts.

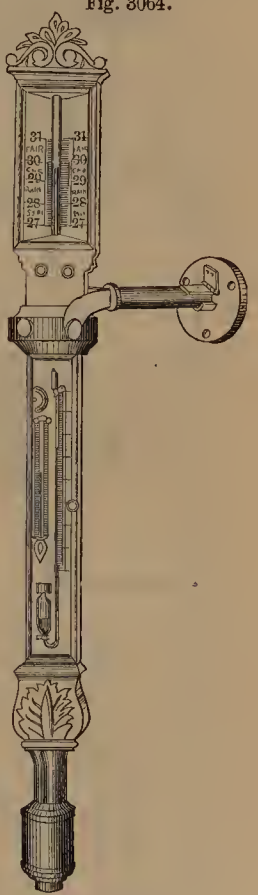
Mar'cus. A large iron-headed hammer.

Mar'gin. 1. (*Roofing.*) The exposed portion of a slate, tile, shingle, or clapboard, when secured on the roof. The width of the margin is the *gage*. The hidden portion is the *cover*. The amount which the slate or shingle of the second course above overlaps a given course is the *bond* or *lap*. Thus, —

A shingle 18 inches long and 6 inches exposed to the weather has a *gage* of 6 inches, a *cover* of 12 inches, a *bond* of 6 inches.

A slate 27 inches in length and a *gage* of 1 foot will have a *bond* of 3 inches.

Fig. 3064.



Marine Barometer.

2. (*Carpentry.*) The flat part of the stile and rail of framed work; such as panel-doors. A *lock-rail*.

Mar'gin-draft. (*Masonry.*) A plain surface adjacent to the joints of ashlar, surrounding the pick or hammer dressed middle portion of the face.

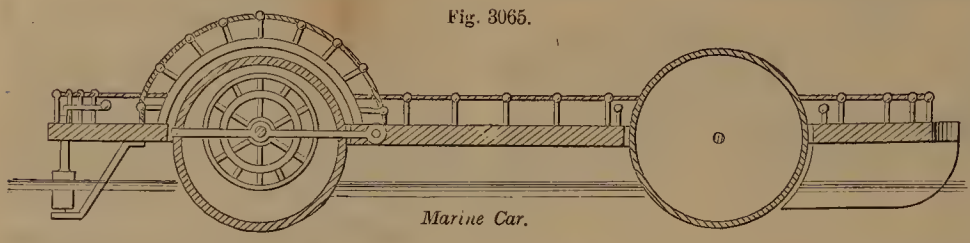
Mar'i-gold-win'dow. (*Architecture.*) A catherine-wheel window.

Mar'i-graph. An apparatus for registering the hight of the tides. A *tide-gage*.

Ma-rine' A-larm'. See BILGE-WATER ALARM; FOG-ALARM. See also list under ALARM.

Ma-rine' Ba-rom'e-ter. A barometer suspend-

Fig. 3065.



Marine Car.

ed in gimbals, and attached by an arm to some upright fixture of the ship, enabling it to maintain a vertical position during the rolling and pitching motions of the vessel.

Ma-rine' Boil'er. One adapted for the use of steam-engines on sea-going vessels. See MARINE STEAM-BOILER.

Ma-rine' Car. A floating vessel with a platform supported upon flotative revolving drums and propelled by a paddle.

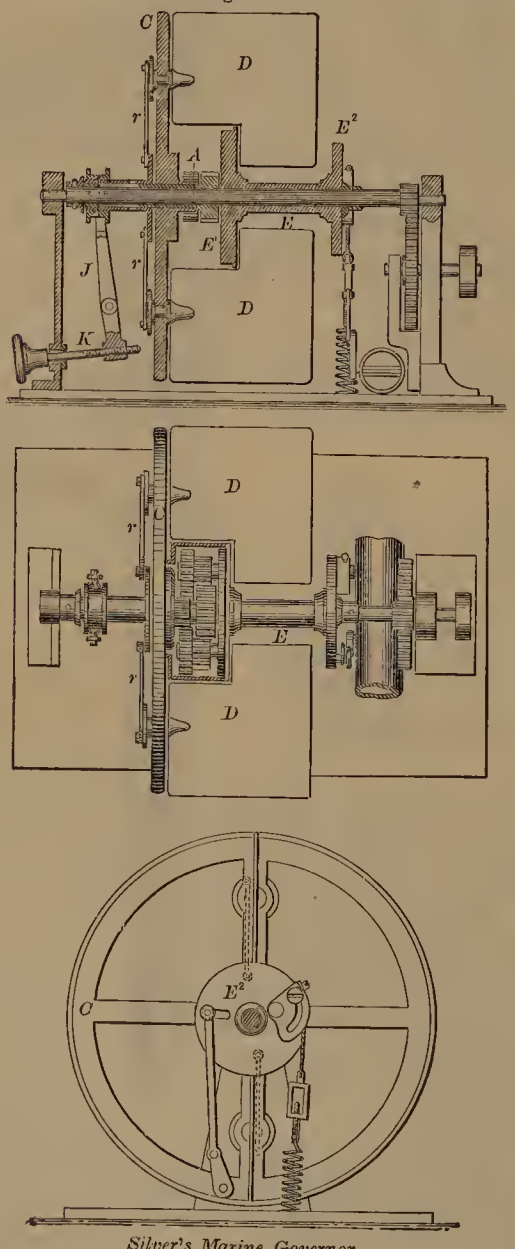
Ma-rine' En'gine. A steam-engine to propel a sea-going ship. There are various kinds of them: the beam, direct-acting, oscillating, trunk, high-pressure, etc. See p. 1399.

Ma-rine' Glue. A composition of caoutchouc, shellac, and mineral oil.

Ma-rine' Gov'ern-or. A governor for marine engines, intended to overcome the effects of the motion of a vessel on a governor of ordinary construction.

Silver's marine governor (American), in use in the British navy, is shown in Fig. 3066. It was patented in the United States, October 2, 1866. A somewhat similar governor was patented in England by Mr. Silver, May 23, 1857, and in the United States April 26, 1859, and reissued to him July 25, 1865.

Fig. 3066.



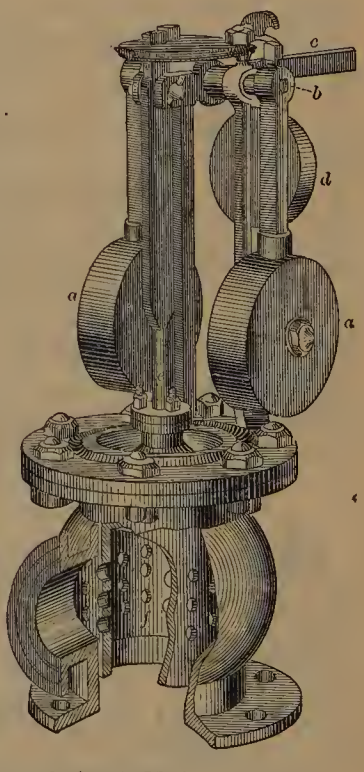
Silver's Marine Governor.

In the form shown, the governor consists of a momentum or fly wheel *C*, revolving loosely on the shaft *A*. The fly-wheel carries vanes or fans *D D*, which may be adjusted to present a greater or less surface of resistance to the air, by means of the screw *K* and levers *J r r*. The sleeve *E* and its collar *E'* also rotate loosely upon the axis *A*, and parallel with the fly-wheel. This sleeve is drawn backward against the motion of the fly-wheel by a spring, which has a tendency at all times to open the throttle-valve. The tension of the spring is regulated by an eccentric segment bolted to the collar E^2 of the sleeve *E*.

The collar *E'* bears two gear-wheels on pins in its face extending toward the fly-wheel, which gear with a fixed wheel on the shaft *A*, and again, at a different speed, with a gear on the fly-wheel.

The vanes are set and gearing adjusted so that the fly-wheel will maintain a nearly uniform velocity. When the driving-shaft exceeds its normal rate of speed, the collar *E'* is carried forward relatively to the fly-wheel, and instantly closes the throttle-valve. A slackening of speed of the driving-shaft permits the spring to turn the sleeve in a contrary direction and open the valve, — the fly-wheel remaining all the time the unit of motion, and maintaining a nearly uniform speed, due to its momentum, the variable pressure of its fans, and its free attachment to the driving-shaft.

Fig. 3067.



Cathcart's Marine Governor.

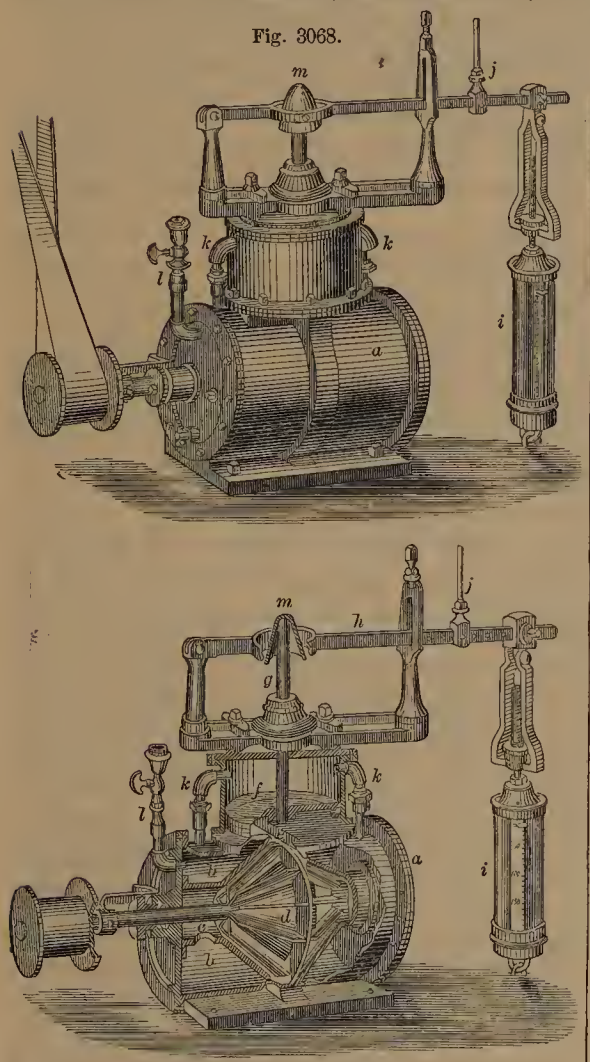
Osborne's marine governor operates by the force of a volume of mercury or other heavy, viscid fluid in a revolving vessel, acting upon a number of vanes held in position against a current of a given force by a spring. Any increase in the speed

of the revolving vessel beyond its normal rate overcomes the force of the spring, turns the vanes, and closes the throttle-valve by a mechanical connection. *Per contra*, if the revolving vessel moves slower, due to a slackening of speed of the engine, the spring overcomes the vortex in the vessel and opens the valve.

Cathcart's marine governor is designed for screw-propellers, to prevent racing of the screw when the ship pitches. It is constructed with pendulous weighted arms *a a* depending from a rock-shaft *b*, on which is keyed a beam *c*, carrying at one end an adjustable counterbalance *d*, and connected at the other end by a rod *e* with a sliding-valve *f*, or a throttle of any form. As the arms *a* swing forward by the pitching of the vessel, the throttle-valve is partially closed, and by this means passage of steam is regulated in proportion to the immersion of the screw.

Duff's marine governor (Fig. 3068) operates by the

Fig. 3068.



Duff's Marine Governor.

force of a centrifugal pump in a vessel of oil. *a* is the exterior case, inclosing chambers *b b*, from which passages *c* lead to an inner chamber. In this chamber there is a centrifugal wheel *d*. The chamber in which this wheel revolves communicates with a piston-cylinder by means of an annular passage *e*. *f* is a piston which raises a stem *g*. Through this stem downward pressure is transmitted to the piston from the lever *h*, which is pressed downward by a spring-balance *i*. Through the rod *j* power is taken off to control the throttle-valve or cut-off valve-gear. Pipes *k* form the communication between the space above the piston and the chamber *b*. Through the pipe *l* oil is put into the outer chamber *b*. The lever *h* transmits its pressure to the stem *g* by means of a pivoted conical cap *m*.

The centrifugal wheel *d* being put in motion by a belt from the engine, the oil in the outer chamber passes in through passages *c* to the inner chamber, whence it is forced through the annular passage into the cylinder under the piston. The pressure on the piston depends upon the speed of the centrifugal wheel, which is much higher than that of the engine, and therefore much more sensitive to change in velocity.

In another governor for marine engines steam in regulated quantity is admitted to an auxiliary regulator-engine, whose rate is therefore constant. This engine is connected by mechanism with the main engine, so that discrepancies in rate will affect the admission of steam to the main engine. — *London Engineer*, Vol. VIII. p. 347.

The chronometric governor is one which has also been adapted to this purpose. In it a time-measurer, such as a clock, is set to work at a prescribed rate, and is so connected to some moving portion that any discrepancy in the respective rates shall act upon a third portion whose motion is communicated to the throttle. Mosman's is of this character: one of two shafts is regulated by a balance-wheel, and the other has motion directly from the engine. A variation in rate of motion causes a longitudinal motion of the shaft which is connected to the governor-valve.

The electro-magnetic marine-governor of Captain Wolcott, U. S. A., is intended to prevent the racing of the screw when the propeller rides out of water when the vessel pitches. The throttle-valve is under the command of a weight when a detent is removed by an armature on the breaking of an electric circuit. The poles of a pair of wires are conducted aft to a point, say a little above the level of the screw, and, when they are submerged, the electric circuit is complete through the water. When the vessel pitches and the poles ride out of the water the circuit is broken, the armature drops away from the magnets, the detent of the weight-pulley is released, and the throttle-valve is closed. When the poles of the wires again dip into the water, the armature closes and the valve is again opened.

Ma-rine' Rail'way. One on which a vessel is hauled up for repairs.

Mar'i-ner's Com'pass. The mariner's compass has a magnetized bar of steel, called the *needle*, having at its center a cap which is supported upon the sharp point of a pivot-post. To the needle is attached a circular card with the cardinal points and minor divisions marked upon it; the number of *points* or *rhumbs* being 32, and these being subdivided into *half* and *quarter points*. A point is 11° 15′, and outside the circle of points is a circle of degrees.

The pivot rises from the center of a box called the *compass-box*, and this is hung by *gimbals* in the *binnacle*, so that the box may always retain a horizontal position, notwithstanding the pitching and rolling of the vessel. The *needle*, the *card*, *rhumb-card*, *compass-card*, or *fly*, is free to float around according to its magnetic impulse, and a mark on the front side of the circumscribing ring shows the direction of the ship's head. The *dab* is the socket of the needle on the pivotal pin.

A is a vertical central section of the compass, as hung in gimbals.

B is a view looking down upon the same.

C is a chart showing the compass notation. The

marks are known as cardinals, N. S. E. W., and intervening are the other 28 points.

D is the Chinese compass-card.

The needle of the Chinese compass is very short and light, not exceeding an inch in length, and so much of its weight is below the point of suspension, that it is but little affected by the *dip* or inclination. The means of suspension is a steel point rising from the bottom of the wooden compass-box and entering a hemispherical copper cup attached by copper strips to the needle.

Fig. 3069.

Mariner's Compass.

Sir George Staunton, who accompanied Lord Macartney in his embassy to China, describes it in his account of the embassy: "Upon the upper surface of the box are drawn several concentric circles, distinguished by different Chinese characters. The eight marks on the inner circle mark the cardinal points, south, north, east, west, and the bisecting intermediate points. The same eight characters also signify equal divisions of the natural day, so that the instrument answers to some extent the purpose of a dial, each division marking three hours. The Chinese character for *sunrise* is the same as that for *east*, and in this form was the first compass which found its way to Europe in the beginning of the fourteenth century. Other circles have 12 and 24 divisions, with characters which mark corresponding portions of the heavens and of the natural day. Each of the latter portions embraces 15° of the 360° into which the circle has been arbitrarily divided in correspondence with the supposed number of days in which the sun performs his apparent course. The remaining circles around the compass contain the characters of the cycle of 60 years, by which this nation regulates its chronology, and other characters expressive of their philosophical and mythological doctrines. The ornamented end of the needle is the south pole, to which this nation gives the preeminence. *South* and *north*." The compass is known as the *Ting-nan-ching*, or "needle pointing to the south." The Chinese were acquainted with the declination of the needle, and were aware that it is not the same in all countries nor invariable in the same place.

The Chinese compass is probably the first portable time-indicator; not absolutely accurate, especially in the different latitudes of that country, but still possessing value as an approximation to correctness.

The mariner's compass originated in China.

The Chinese word *Tchi-nan* (*the southern pointer*), indicates the Chinese practice of considering the *south* the principal cardinal point. The Emperor's throne and all government edifices in China are made to face the south, and the needle is said to point south and north, the former having the preeminence in expression.

Among the Chinese, Thibetans, and Mongolians the *south* is mentioned before the *north*, and in Chinese and Mongolian the *west* before the *east*. In Mongolian the word *south* means *front*, *north* is *behind*, *west* "to the *right*," *east* "to the *left*." The Chinese character for *north* is two men turned back to back, and originally meant "to turn the back upon." The Hebrew practice was different; with them the words *before*, *behind*, *right*, *left*, are used, but the *east*, the rising sun, is in front; a distinct trace of the Baal (sun) worship to which they so constantly recurred, in sympathy with the Phœnicians and Canaanites. "The sea" was sometimes used as a term for the west, meaning the Mediterranean, which was behind when the sun was faced. With us, the north is supposed to be faced in giving the points of the compass in their order; *boxing the compass*. The Hawaiians front the west, and call north *right*, south *left*.

The Chinese chronicles of Szuki of Szumathsin, written in the second century before our era, state that 900 years before, Tsching-wang, the Emperor of China, gave "*magnetic cars*" to the ambassadors of Tonquin and Cochin China, in order that they might "not miss their way on their return home."

In the forward part of the magnetic car was a floating needle, the motions of which were communicated to a small figure whose outstretched arm and hand pointed toward the south. It was used as late as the fifteenth century A. D., and the cars, carefully preserved in the imperial palace of China, were used in determining the point toward which the main sides of the public buildings should be directed.

It thus appears that the compass was first used by

land travelers, which, as Humboldt remarks, is a singular fact. It was, however, used on board vessels in the Chinese seas in the fourth century A. D. and probably much earlier. The effect of the loadstone on iron is noticed in a Chinese dictionary, A. D. 121; and another work states that "fortune-tellers rub the point of a needle with a loadstone to give it the power of indicating the south." The Japanese say that at a time corresponding to A. D. 543, the "wheel which shows the south" was sent to the Mikado from the court of Petsi in Corea.

From China to India was in the natural order of trade, a route which has been followed by many arts, such as the glazing of tiles and pottery, the manufacture of sonorous bronze, gunpowder, etc. When Mahmoud of Ghazni invaded India, several arts were scattered abroad and found their way still farther to the westward; the immediate introducers into the countries bordering on the Mediterranean being the Arabs, whom many have credited with the invention of arts which they derived from the farther East. The Arabic designations of *Zoron* and *Aphron* (south and north), which Vincent of Beauvais gives to the two ends of the magnetic needle, indicate the source whence the compass was directly obtained; and the influence of this people in the science of astronomy is also indicated in the Arabic names of many stars which are still retained.

"The dwellers in the West received, through the Macedonian settlements, accurate accounts of Indian productions of nature and of art, of which little more than the names were previously known by reports derived either through more ancient commercial connections, or through Ctesias of Cnidos, who had lived for seventeen years at the Persian court as the representative of Artaxerxes Mnemon. Such were the watered rice-fields, of the cultivation of which Aristobolus gave a particular account; the cotton-shrub, and the fine tissues and paper for which it furnished the materials; spices and opium; wine made from rice, and from the juice of palms, the Sanscrit name of which, *tala*, has been preserved by Arrian; sugar from the sugar-cane, which, indeed, is often confounded by the Greek and Roman writers with the *tabaschir* of bamboo stems; wool from the great Bombax trees; shawls from the wool of the Thibetian goat; silken (*Seric*) tissues; oil of white Sesamum (Sanscrit, *tila*); oil of roses and other perfumes; lac (Sanscrit, *lakscha*, and in the vulgar tongue, *lakkha*); and, lastly, the hardened Indian *wootz* steel." — HUMBOLDT.

During or before the twelfth century A. D., the mode of suspending the needle had been improved in China, by hanging it upon a silken thread instead of floating it on water. At this period the Chinese philosopher, Keon-tsoung-chi, observed the variation of the needle, which was again noticed by Columbus in 1492, and by Sebastian Cabot in 1540. The Chinaman says: —

"A point of iron touched by the loadstone receives the power of indicating the south; still it declines towards the east, and does not point exactly towards the south."

French observations at Pekin confirm this, only stating it to be a variation from the north of 2° to 2° 30′ to the west; while the Chinese, insisting on their mode of stating it, set it down as being from 2° to 2° 30′ to the east.

Columbus first noted a line of no variation about 100 miles west of the Azores.

It is a remarkable fact that the earliest European writer on terrestrial magnetism, William Gilbert, whom we cannot suppose to have had any knowledge of Chinese literature, regards the mariner's compass as a Chinese invention which had been brought to Europe by Marco Polo.

The compass of the Phœnicians is believed to have been a needle buoyed by a slip of pith and floating in a cup. That of the Arabs was described in 1242 by the Arabian Boulak Kibdjaki.

"Among the properties of the magnet, it is to be noticed that the captains who sail in the Syrian waters, when the night is dark, take a vessel of water, which they shelter from the wind, upon which they place a needle buried in the pith of a reed, and which thus floats upon the water. They then take a (*magnes*) loadstone as big as the palm of the hand, or even smaller; they hold it near the surface of the water, giving it a rotary motion until the needle turns upon the water; they then withdraw the stone suddenly, when the needle with its two ends points north and south. I saw this with my own eyes on my voyage from Tripoli in Syria to Alexandria in the year 640 [640 of the Hegira, 1240 A. D.]. I heard it said that the captains in the Indian seas substitute for the needle and reed a hollow iron fish, so magnetized that when placed in the water it points to the north with its head and to the south with its tail. The reason that the fish swims, not sinks, is that metallic bodies, even the heaviest, float when hollow and when they displace a quantity of water greater than their own weight."

Worthy Arabian; we have here a description of a magneto-electric needle used in the Levant; a magnetized floating needle used in the Indian Ocean; and a correct statement of the Archimedean discovery of specific gravities. This was written about the time of Roger Bacon, 250 years before Da Vinci, 350 years before Porta, and more than 400 years before Galileo and Newton.

The Phœnicians circumnavigated Africa in the seventh century B. C., as we learn from Herodotus.

Strabo (writing about A. D. 18) says: —

"If the extent of the Atlantic Ocean were not an obstacle, we might easily pass by sea from Iberia [Spain] to India, still keeping in the same parallel."

So Christopher Colon reasoned. See MAP.

It thus appears that the Arab needle had only temporary polarity, and this was probably the case with the Phœnician. It was consulted by the captain, and not kept in a binnacle like the Chinese and the modern needle.

Hercules, the symbol of Phœnician enterprise, in his colossal statue at Tarentum, referred to by Pliny, is represented with a key in one hand and a bowl in the other. The cup he is fabled to have received from Apollo, and in it he floated his polarized needle.

The name of Hercules is given to the stone *magnes*. The needle is probably the "arrow of Abaris." This supposition adds interest to this ancient classical symbol.

In 1190, Guyot of Provence wrote a satirical poem, called "La Bible," in which he refers to the use of the magnetic needle.

Between 1204 and 1215, Jacobus of Vitry, Bishop of Ptolemais, referred to it in his description of Palestine, as follows: —

"The loadstone is found in India, to which, from some unknown cause, iron spontaneously attaches itself. When an iron needle is touched by the stone, it at once points towards the North Star; from whence it has become useful to those who navigate the seas."

Latini of Florence, the preceptor of Dante, in a work published in Paris in 1260, entitled the "Treasure," wrote thus: —

"When I was in England, Friar Bacon showed me a magnet, — an ugly black stone to which iron doth willingly cling. You rub a needle upon it;

the which needle, being placed upon a point, remains suspended and turns against the star, even though the night be stormy and neither star nor moon be seen; and thus the mariner is guided on his way."

The Italian Riccioli, in his work upon Geography and Hydrography, states that before 1270 the French mariners used "a magnetized needle, which they kept floating in a small vessel of water supported on two tubes so as not to sink."

The magnetic needle is mentioned by Peter Adsiger in a Latin essay in 1269, in which the south pole is said to vary a little to the west; and by Raymond Lully of Majorca, in his "Fenix de las Maravillas del Orbe," published in 1286.

A passage in the Spanish "Leyes de las Partidas" of the middle of the thirteenth century runs as follows: "The needle which guides the mariner in the dark night, and shows him how to direct his course both in good and bad weather, is the intermediary between the loadstone and the North Star."

Dante, about 1300, refers to the needle "which points to the star."

Marco Polo, the great traveler, was in the service of Kublai Khan, the conqueror of China, from 1274 to 1291, and was concerned in the introduction of the compass from China to Europe direct. It had previously arrived by the good old channel, India and Arabia; but Marco Polo did not know that, and his services can hardly be exaggerated.

The Arabs sailed by the compass during the Khalifate of Cordova, which lasted till A. D. 1237, when it was subdued by the Moors. An authority states that it was known in Norway previous to 1266.

Dr. Gilbert, physician to Queen Elizabeth, states that P. Venutus brought a compass direct from China in 1260.

See Klaproth's work on this subject, Paris, 1834; Sir Snow Harris's "Rudimentary Magnetism"; the researches of Biot, Stanislaus Julien, etc.

About 1320, Flavio Gioja, a pilot of Positano, not far from Amalfi in the Kingdom of Naples, was instrumental in the improvement of the compass, and for a time passed as the inventor thereof. Such a claim is fully disposed of by the facts above cited.

It is probable that Gioja was a skillful mechanic, and improved upon the popular modes of supporting the needle (which were by floating it, or suspending it by a cord), and placed it upon a pivot-post in the center of a marginal strip, which was marked with the cardinal points and minor divisions. This rendered it more convenient for reading, and gave a certain steadiness to the needle.

Vasco da Gama, who circumnavigated Africa, doubling the Cape of Good Hope, November 20, 1497, testifies his surprise at meeting in the Indian Ocean seven small Arab vessels provided with the compass, quadrants, sea-charts, and other instruments, equal to the Portuguese. We do not wonder, for the China seas had been navigated by their aid over 1,000 years when the brave navigator repeated the feat of the mariners of Pharaoh Necho, about 610 B. C.

The gimbal-joint and compass-box were invented by the Rev. William Barlowe in 1608.

The *dip* of the needle was discovered by Robert Norman of London, 1576; the diurnal variation, by Graham, a London watchmaker, in 1722.

An azimuth compass is one used at sea for finding the horizonal distance of the sun or a star from the magnetic meridian.

Lord Caithness has substituted for the gimbals a pendulum and a ball; the latter working in a socket in the center of the bottom of the compass-bowl.

Albini's self-registering compass is an instrument by which a continuous record is kept of the course steered by the vessel on board which the compass is placed. The compass-card carries on its under side, and near its periphery, a number of types or letters, which correspond with those denoting the points of the compass on the upper surface of the card. A continuous strip of paper, moved by clock-work, passes under the card at that side which is next the bow of the vessel, and between this paper strip and the card itself is an inked tape, which also travels slowly. At frequent regular intervals the compass-card is tilted, so as to bring the type which happen to be immediately above the paper strip at the time down upon the inked tape, bringing the latter in contact with the paper, and marking upon the latter the letters denoting the course which the vessel is steering at that moment.

When iron ships were first introduced, great difficulty was experienced in regard to the disturbance of the compass, owing to the vicinity of large bodies of iron. It was also shown by Grantham in 1842, and Scoresby in 1851, that the direction of the ship's head on the stocks, the effect of riveting in that position, the magnetic direction while fitting, each had an influence in determining the magnetic condition of the vessel.

Compasses are sometimes carried on the masts of iron vessels as a means of removing them from the disturbing influence of the iron of the hull. In this position they serve as standards of comparison for the binnacle compass.

The amount of deflection of the needle from its proper direction frequently varies on each point of the compass; while on one course it may indicate correctly, on another it may err from one to two points. The amount of this deviation is ascertained by anchoring the ship in a smooth and sheltered place with a very short scope of cable, and carrying out kedges so that she may be swung round and held in any required position.

The magnetic bearings of one or more conspicuous objects, at a sufficient distance to obviate any sensible parallax, are taken from the map or chart; the ship is swung, by the means before indicated, so that her head shall point successively to every point of the compass, and as the ship's head, during the operation of swinging, is brought in line with the object above mentioned, the compass bearing is noted, and at the same time angles are taken with the sextant to other distant objects on shore, whose position is known. A comparison of these angles with the bearings indicated by the compass shows at once the error of the latter.

Local deviation is not exclusively confined to iron ships; it is frequently quite perceptible in wooden men-of-war, occasioned by the attraction of the guns, and in vessels laden with iron the amount is often very great.

Professor Airey's method of adjusting compasses in iron ships is essentially as follows. Directly under the spot where the compass is to be placed two lines are drawn on the deck, one parallel with and the other perpendicular to the line of the keel. Two or three powerful magnets and one or two small boxes for holding chain are provided. The vessel's head is brought in the direction of one of the cardinal points, as ascertained by a compass on shore free from disturbing influences, and she is held in this position by hawsers. If the ship's compass indicates any deviation from the true bearing, one or more of the magnets is placed upon the deck at right angles to the magnetic meridian and moved backward or forward until the compass-needle indicates correctly. The ship's head is then turned 90°

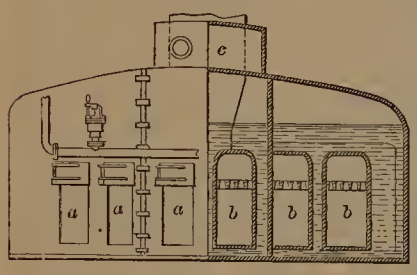
and the operation repeated until the compass-needle again points correctly. A similar process is employed to bring the needle into coincidence with the meridian at each of the other cardinal points indicated by the cross lines on the deck, and its correctness at each of the four rhumb points, N. E., N. W., S. W., S. E., is assured in like manner, using the boxes of chain before mentioned to correct the deviation of the needle. When these adjustments are made the compass should be sufficiently correct for all practical purposes. The deviations, if any, may be ascertained by swinging the ship.

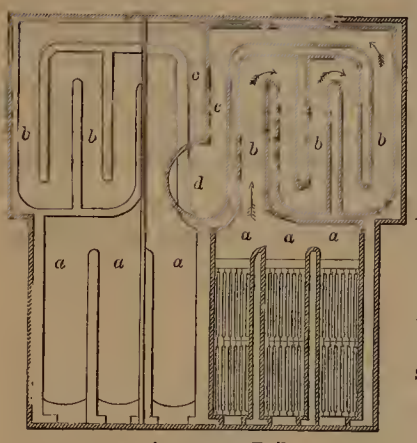
Gray's apparatus for adjusting compasses is based on the foregoing method of Professor Airey. The regulating magnets are caused to approach or recede from the compass by screws, so as to admit of very accurate adjustment.

Great care must be taken that the magnets are brought, by turning the ship at right angles, to the magnetic meridian before moving them, in order to regulate the compass.

Ma-rine' Steam-boil'er. Marine steam-boilers are composed of an external shell or casing, with rectangular sides, stayed together by tie-bars. Within it are contained the furnaces, the flues and ash-pit, the whole being surrounded by water except at the furnace front.

Fig 3070.





Marine Steam-Boiler.

In some cases, the front is also water-jacketed, and the doors themselves are filled with water, circulation being maintained through the tubular hinges.

The flues for the passage of flame and smoke are deep rectangular channels, which, after making many turnings, unite in one common chimney or funnel.

The marine boiler shown in the illustration is composed of three parts, the sides of the middle boiler serving as a side to each of the outside boilers. At some distance above the water-line, large apertures are cut in the sides of the middle boiler, to form a steam communication between the three compartments, and a water communication is established below by a pipe from each boiler, opening into the blow-off main. The upper figure is an elevation, one half in section; *a a* are the fire-doors and *b b* the fire-chambers, *c* is the steam-dome.

Each boiler has two fireplaces, and the flues *a a* (lower figure) of the side boilers branch into the flues *b b* of the contiguous fireplaces of the middle boiler, immediately at the back of the bridge; and, after taking the circuitous course shown in the plan by the arrows, they unite at the back of the boiler and form one large flue *e*, from which the chimney *d* rises at about the middle of the length of the boiler. The flues are not divided horizontally, but extend the whole depth from *b* to *b*, as shown in the vertical section.

Towards the forepart of the middle boiler is a steam-chest, from whence proceeds the main steam-pipe, which conveys the steam to the cylinders. The feed-pipe and feed-valves are shown in the sectional view.

The separation between the boilers extends a considerable distance above the water-line, in order that their contents may not all be collected on one side of the vessel when she careens or rolls, uncovering some of the weathermost flues.

At the bottom of the boiler are pipes passing through the vessel's sides, and furnished with stop-cocks or valves, by which sediment or brine may be blown out of the boiler.

Mud-holes are used for cleaning out scale or sediment, and at other times are closed by doors.

In the *marine* steam-boiler the fire and flues are all contained within the boiler itself, and are surrounded by water in every direction as a precaution against fire. There are many varieties, known as *flue*-boilers, *tubular* boilers, *sheet-flue* boilers, etc.

Ma-rine' Steam-en'gine. A form, or one of the forms, of steam-engines adapted to use on shipboard.

The objects to be gained in the modification of the land engines to suit the change of circumstances are, —

Compactness, to save room on board and secure protection below decks.

A *low center of gravity*, to increase the stability of the vessel.

Napier's side-beam engine is the form which has been extensively adopted in paddle-wheel vessels, and is the one selected for illustration.

A modification of this is found in the *lever-engine*.

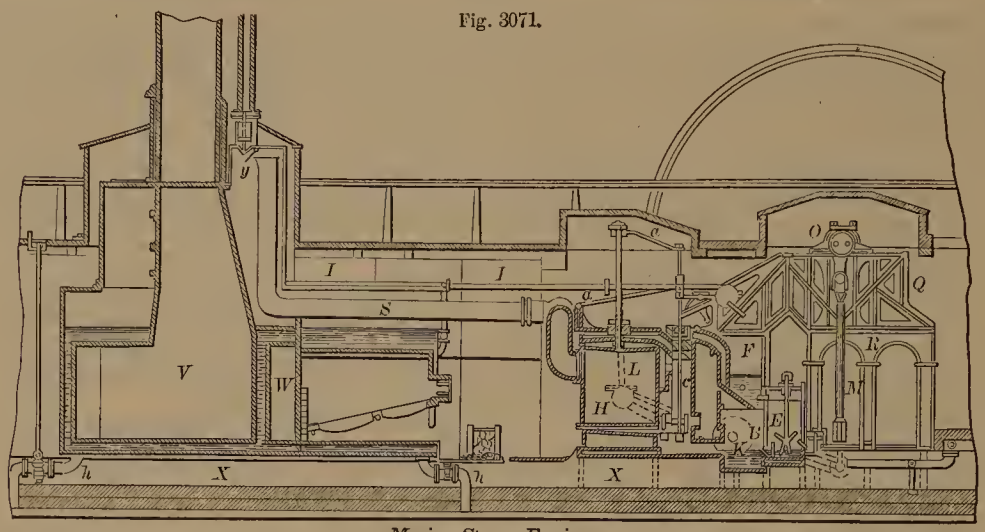
An endeavor to dispense with the beam has originated a variety of *direct-action engines* and *oscillating-cylinder engines*.

The figure represents in section a *side-beam engine* with a flue boiler as placed in a steam-vessel.

The sleepers supporting the engine are represented at *X*, and the base of the engine is secured to these by *holding-down bolts* passing through them. *S* is the steam-pipe leading from the steam-chest in the boiler to the slides *c*, by which it is admitted to the top and bottom of the cylinder. The condenser is represented at *B*, and the air-pump at *E*. The hot-well is seen at *F*, from which the feed is taken to the boiler. *L* is the piston-rod connected with the beam *H*, working on a center *K* near the base of the engine. The other end of the beam *H* drives a connecting-rod *M*, which extends upward to the crank on the paddle-shaft *O*. *a a* are the rods of the parallel motion. The framing by which the engine is supported is represented at *Q R*.

The beam exhibited in the figure is shown in dotted lines, as being on the farther side of the engine. A similar beam, similarly placed and moving on the same center, must be understood to be on the near side also, connected with the cross-head of the piston in like manner by a parallel motion, and with a cross-tail attached to the lower end of the connecting-rod and to the opposite beam. The eccentric which works the slides is placed upon the paddle-shaft *O*, and the connecting arm which drives the slides may be easily detached when the engine requires to be stopped. The section of the boiler, grate, and flues is represented at *W V*. The safety-

Fig. 3071.



Marine Steam-Engine.

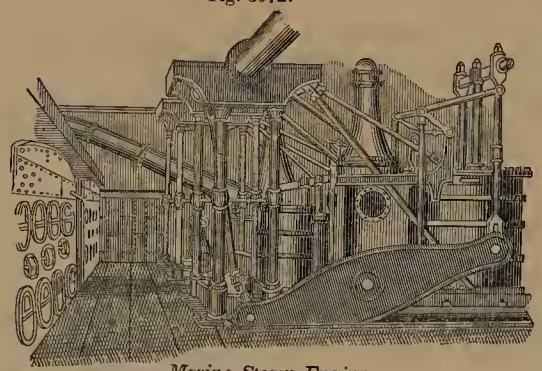
valve *y* is inclosed beneath a pipe carried up beside the chimney, and is inaccessible to the engineer. The cocks for blowing off the salt-water from the boiler are represented at *h*, and the feed-pipe at *I*.

Fig. 3072 is a view of a similar engine, looking down the alley between the boilers and the working parts.

The side-beam engine is very compact compared with the elevated working-beam engine, such as the *Cornish*, for instance, but the tendency of late years has been to direct action, dispensing with the beam.

The general adoption of the screw propeller has also much changed the general conditions required,

Fig. 3072.



Marine Steam Engine.

and oscillating engines of large diameter and comparatively short stroke are now the order of the day.

The following list includes most of the varieties of engines specially adapted to marine purposes. See under the respective heads : —

Annular-cylinder steam-engine.
Direct-action steam-engine.
Double-cylinder steam-engine.
"Gorgon" steam-engine.
Inclined-cylinder steam-engine.
Inverted-cylinder steam-engine.
Inverted double-cylinder steam-engine.
Lever steam-engine.
Oscillating-cylinder steam-engine.
Propeller steam-engine.
Screw-propeller steam-engine.
Side-beam steam-engine.
Sliding-cover steam-engine.
Steeple steam-engine.
Trunk steam-engine.

Mar'i-no-ra'ma. A picture of a sea-view.

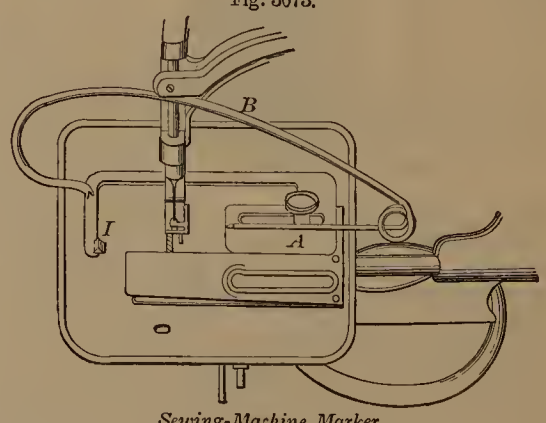
Mark. 1. Marks of manufacturers, sometimes termed trade-marks, or marks of merchandise. These marks are protected by all modern civilized nations, and, in fact, by the whole commercial world. The mark of the artisan is found upon the most ancient fabrics that have come to light. The Chinese, the Persians, the Egyptians, all had their distinctive manufacturers' signs, symbols which were intrinsic evidence of genuineness of origin of the articles of merchandise to which they were affixed. In the ruins of Herculaneum and Pompeii they are found. The Romans brought them to Britain, where the practice of using them has continued, probably without any intermission, from their time to our own. Antique pieces of pottery found in England furnish example. All nations protect the manufacturer in the exclusive use of his private emblem, and, by treaties, statutes, and judicial decisions, the most stringent penalties are inflicted upon one who pirates such a mark for his own fraudulent gain. The mark is, in fact, the commercial signature of the maker. All the early printers had their trade-marks, generally monogrammatic.

2. (*Nautical.*) One of the notifications of depth, on a sounding-line. See MARKS AND DEEPS.

Mark'er. An attachment to a sewing-machine for forming creases in or marks on fabric, so that it may be folded in line with such crease or mark for a tuck, and in a line parallel with, and at any desired distance from, another tuck.

Fig. 3073 shows a good form of the appliance. The plate *A* has an arm surrounding the feed-open-

Fig. 3073.

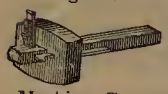


Sewing-Machine Marker.

ing and presser ; on the end of the arm is the spur *I*. An arm *B*, notched at its forward end, is bent to form a spring, and is bent down by the needle-bar to form a crease in the cloth lying on the point *I*. For varieties of *tuck-creasers* and *markers*, see "Sewing-Machine Attachments," G. W. Gregory, Washington, D. C.

Mark'ing-gage. (*Carpentry.*) The marking-gage has a stem which carries a scribing point and a head or fence, which is adjustable on the stem and secured in adjustment by a set screw or wedge. As the scribe is drawn along on a board, the *fence* slides on the edge of the latter, and causes the mark to be parallel with the edge and at the regulated distance.

Fig. 3074.

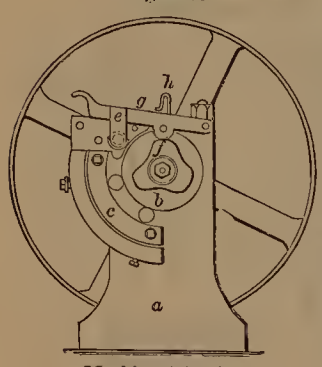


Marking-Gage.

Mark'ing-ink. An indelible ink for marking clothes. See INK.

Mark'ing-ma-chine'. (*Coining.*) A machine used in the mint, to swage the edges of planchets for coin, raising the edge of the blank preparatory to *milling*. *a* is an iron frame in which is a horizontal shaft carrying a driving and a loose pulley and a fly-wheel; *b* is a flat, circular plate with a grooved edge; *c* is a plate with corresponding grooved edge, adjustable to the plate *b* by screws, and *e* a hopper in which the blanks are placed; *f* is a cam which, as it revolves, pushes back the feeder *g*, allowing the blanks to fall from the hopper. The spring *h* brings down the feeder *g*, which pushes a blank from the bottom of the hopper. The blanks slide down an inclined plane until their edges come between the plates *b* and *c*, and as the plate *b* revolves, the pressure of its edge carries them forward, and at the same time raises their edges all around, increasing the thickness by about one third.

Fig. 3075.



Marking-Machine.

Mark'ing-plow. (*Agriculture.*) One for running slight furrows in plowed land as a mark for planting corn, or, at greater distances, for sowing broadcast. Also used in crossing out land for planting an orchard.

Marks and Deeps. (*Nautical.*) The mode of indicating lengths on the hand lead-line. The *marks* have certain indications. The *deeps* are the estimated fathoms in the intervals of the *marks*.

Mark 2, leather.	Deep 12.
Mark 3, blue bunting.	Mark 13, blue bunting.
Deep 4.	Deep 14.
Mark 5, white bunting.	Mark 15, white bunting.
Deep 6.	Deep 16.
Mark 7, red bunting.	Mark 17, red bunting.
Deep 8.	Deep 18.
Deep 9.	Deep 19.
Mark 10, leather.	Mark 20, two knots.
Deep 11.	

Marle-stock. An English name for a kind of brick. A *cutter*.

Mar'line. (*Nautical.*) A small cord composed of two strands slightly twisted and used for lashing, sewing, and tricing. Used either white or tarred.

Marl'ing. (*Nautical.*) Wrapping a rope with spun-yarn or twine, having a knot at each turn to secure it if it become cut at one or more places. It differs from SERVING (which see).

Mar'lin-spike. (*Nautical.*) A pointed iron pin suspended by a lanyard, and used to make an opening between the strands of rope in splicing.

Mar'mo-ra'tion. (*Architecture.*) A casing of marble to a building.

Mar'mo-ra'tum; Mar'mo-re'tum. A cement made of pounded marble and lime for architectural purposes.

A cement of tin-foil and mercury, formerly used for filling decayed teeth.

White of egg and quicklime incorporated in a mortar.

Mar-o-quin'-leath'er. A leather, generally dyed red or yellow, and prepared at Astracan and vicinity. It is made from the skins of bucks and goats. See SAFFIAN.

Mar-quee'. A field tent or covering made of strong canvas to keep off the rain. Generally with a second canvas or *fly* a little above the tent proper.

Mar'quet-ry. Inlaid work. It includes *parquetry*, *reisner* work, *buhl*, *mosaic*.

The first of these is employed in the ornamentation of cabinet and furniture work. In buhl, the patterns are usually more elaborate, consisting of scrolls and similar curvilinear figures, and the works comparatively small, while marquetry proper is used for floorings, etc. The general manner of executing these varieties of work is, however, entirely similar, consisting in cutting the designs out of pieces of wood or plates of metal and inserting pieces of a different color.

The woods employed in marquetry may be of their natural color or stained to any desired tint. The pattern may include figures or devices of any kind. Even pictures or portraits may be produced by the contrast in color or arrangement of the grain of the woods. When the inlays are inserted, the work is reduced to a level surface with the toothing-plane, and then scraped with the joiner's scraper applied obliquely to the joints of the wood. This is sometimes so skillfully done that the work may be polished with its own shavings, but ordinarily the use of glass-paper is required to produce the requisite polish. Works in wood and metal or in pearl, ivory, or tortoise-shell and metals require the use of the file, followed by sand or emery-paper. (See BUHL; PARQUETRY.) This species of ornamentation was much in vogue during the past century, but is now comparatively rare.

The art of inlaying different pieces of wood to resemble mosaic is of great antiquity. It was practiced in Egypt at a remote period, and is shown in very successful condition about 1355 B. C. See the chairs, boxes, mummy-cases, and furniture of Rameses III. in the "Description of Egypt," by the French savans, about 1812. The book is in the Congressional Library.

The art was very popular in India in times of whose dates we can only guess. The Chinese, also, were early in the field, and excelled in this as they did and do in whatever requires patient toil and persistent, careful manipulation.

The Egyptian antiquities referred to embrace many different colored woods and metals. Among the Italian artists, black and white woods were first used, and were called *moreseocs*. John, Abbot of Verona, introduced stained woods, and thereby added to the variety. He also introduced buildings and attempts at perspective representation.

Mar'ron. (*Pyrotechnics.*) A paper box strongly wrapped with twine and filled with powder; it is intended to imitate the report of cannon, and is fired by a piece of quickmatch projecting externally.

Mar-seilles'. (*Fabric.*) A heavy cotton goods, embossed in the loom.

Mar-sel'la. (*Fabric.*) A kind of twilled linen.

Mar-sil'ly-car'riage. A naval gun-carriage having no fore trucks, the front transom resting immediately on the ship's deck. It is used in the

United States Navy for mounting the 9-inch gun in broadside.

Mar'tel-de-fer. A hammer and pick forming a battle-axe, and used in the Middle Ages.

Mar'te-line'. A small stone-hammer (*u*, Fig. 3032) used by sculptors and marble-workers. It is pointed at one end and square or diamond-shaped at the other.

Mar'te-line'-chis'el. A sculptor's chisel, driven by a mallet or hammer, and used by artists or workers in marble. *q r s t*, Fig. 3032, show several forms.

Mar-tel'lo-tow'er. (*Fortification.*) A circular, isolated tower of masonry, named from Mortella Bay, Corsica, where a tower of this description was taken by an English naval force in 1794, after a prolonged resistance.

The capacity for defense excited so much surprise and admiration, that numerous towers were planted along the English, Irish, and Jersey coasts, in anticipation of the invasion of Napoleon I.

The tower is usually about 40 feet in hight, having two stories, and a shell-proof roof with a 4½-foot parapet. The walls are 5½ feet thick; the lower story is for stores, magazine, and retreat; the second is a casemate with embrasures; the roof is armed *en barbette* with a traversing gun, under a bomb-proof. The towers were erected on the coasts of Kent within range of each other.

The entrances are at a considerable hight above the ground, and the tower has a ditch and glacis.

Two of these towers are on the plains of Abraham, as outworks of the citadel of Quebec.

Mar'tin. A grinding-tool consisting of a brass plate with a flat stone facing. An opening through the plate and lining allows sand to pass through and insinuate itself between the *martin* and the stone which is being ground. A *runner*.

Mar'tin-et'; Mart'net. (*Nautical.*) A small line on the leach of a sail, to assist in handling it in furling.

Mar'tin-gale. 1. (*Nautical.*) *a.* A lower stay for the *jib-boom* or *flying jib-boom*.

The *martingale* of the former passes from the end of the jib-boom to the *dolphin-striker*, and is *set up* by *setting taut* the back-ropes of the latter.

The *flying jib-boom martingale* passes from the end of the spar, is rove through the end of the *dolphin-striker*, and is set up in the head of the ship.

b. A perpendicular spar under the bowsprit end, for guying down the headstays of a ship.

2. (*Harness.*) A strap from the nose-band to the girth, to keep a horse from throwing the head or rearing.

Or, a strap passing from the girth or belly-band and forking in front of the chest; at the ends of the bifurcations are two rings for the reins.

Mar'tin's Shells. (*Ordnance.*) Cast-iron spherical shells, lined with loam and cow-hair and filled with molten iron. Used as an incendiary shell.

Marv'er. (*Glass-making.*) From the French *marbre*, marble, a slab of that material being formerly used. A slab of marble or cast-iron, with a polished surface and supported by a stand. Upon it glass is rolled to give it a cylindrical shape. See GLASS-BLOWING. It sometimes has concavities for shaping glassware when blowing.

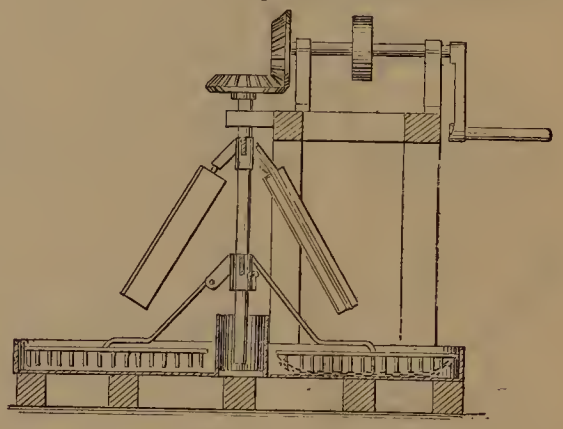
Mash. Crushed or ground grain, malt, or a mixture of the two, steeped in hot water so as to obtain an infusion consisting of the saccharine portions. The resulting solution is *wort*, and when decocted with hops and fermented it becomes beer; when simply fermented, it is *wash* for distillation.

The *mash* of the Scotch distillers is made of 40 bushels of ground barley, and 20 of crushed malt; this is infused in 750 gallons of water, at 150° Fah., for from 1 to 4 hours, and stirred. 500 gallons of water at 190° to 205° are admitted at intervals, to keep up the heat. After mashing, the infusion is allowed 2 hours to settle, and is then decanted.

The grains are repeatedly washed to extract soluble matter, the resulting liquid being boiled down or used as a steeping liquid in future boilings.

Mash-cool'er. A stirring-trough in which mash or wort are stirred to expedite the cooling. The rotary vertical shaft has its fans and stirrers; the former cause a circulation of air, and the latter stir the contents of the shallow circular tub.

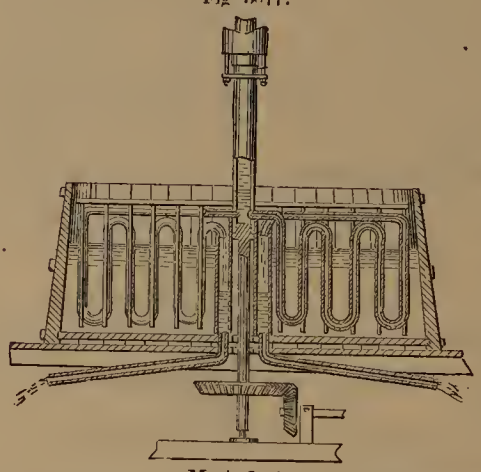
Fig 3076.



Mash or Beer Cooler.

In Fig. 3077, coils of cold-water pipes are supplied from an axial pipe, and discharge into an annular chamber around the axis. The constant stream of water keeps the coils cool as they revolve in the mash.

Fig 3077.



Mash-Cooler.

Mash'ing. Making an infusion of malt (called *wort*) by steeping and stirring in hot water. In the manufacture of vinegar, the cooled *wort* is fermented to form *malt-wash* or *gyle*, which is acetified by *fielding* or *stoving*.

Mash-tun. (*Brewing.*) The vat or cask in which malt is steeped, and from which the saccharine solution is drawn. A mash-tub.

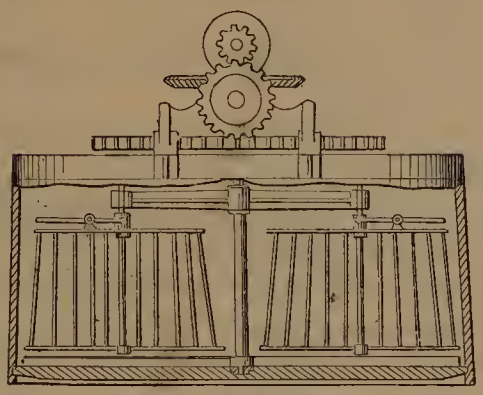
Pliny tells us that the Egyptians made barley wine, because their country, being subject to periodical overflow, was not suitable for grapes. The Gauls also made beer, and, the same historian informs us,

were the first to use yeast for raising dough for bread. The "froth of their barley wine," he calls it. This was probably twelve or fifteen centuries before the people added an infusion of hops to the wort.

Yeast is said to have been first used in England for bread-making in 1550.

Fig. 3078 shows a form of mash-tub which has

Fig. 3078.

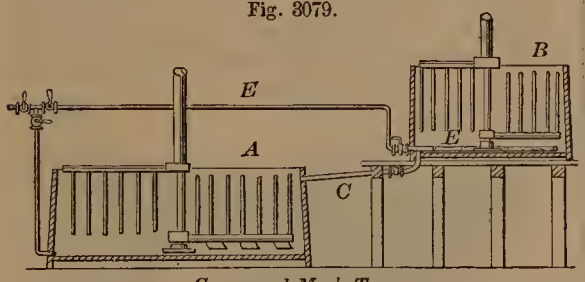


Mash-Tun with Stirrers.

rotating and revolving stirrers at the ends of an arm which is revolved by means of gear-wheels.

Fig. 3079 shows a compound tub for the use of

Fig. 3079.

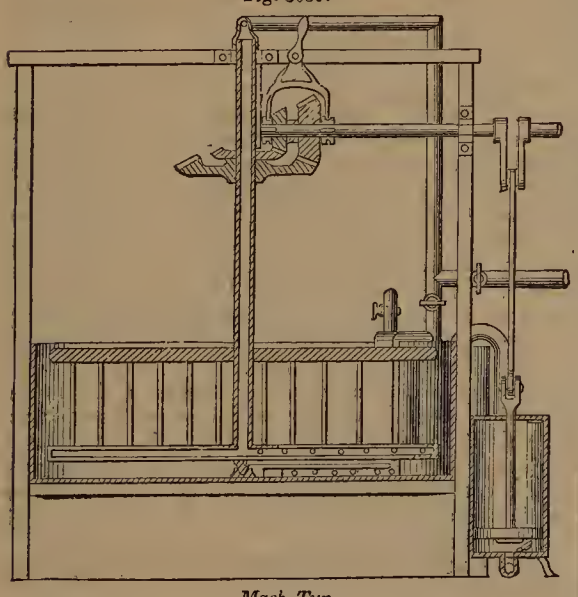


Compound Mash-Tun.

corn-meal with malt in making beer, or for mashing corn-meal to make wash for distilling.

The small tub *B* is placed higher than the large tub *A*, and is filled with water containing a quantity of corn-meal equal to the quantity of malt in the large tub *A*. Steam is admitted to *B* through perforations in the coiled pipe *E* at its bottom, until the corn-meal is entirely dissolved and the liquid is clear, like sirup. The liquid is then drawn off into *A* through pipe *C*, the fluid mass being kept all the time in motion by the stirrers.

Fig. 3080.



Mash-Tun.

In Fig. 3080 the vertical shaft of the rake is hollow, as are also the arms; through perforations in the latter a current of air and steam is poured for the purpose of boiling the wort, and subsequently a refrigerated stream of air for the purpose of cooling it. A stationary perforated pipe in the vat may be the medium of conveying the currents aforesaid.

Mask. 1. A face covering.

a. A wire cage to protect the face from a stray cut or thrust with a foil in fencing.

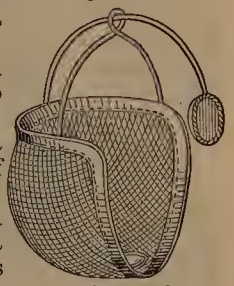
b. A face covering of a humorous or other character as a disguise.

c. A face protection to be worn in glass-works or foundries, to protect against radiant heat.

d. A face covering with a means of arresting particles of metal in dry grinding.

e. A form of inhaler which covers the face and affords a wholesome atmosphere to miners or firemen in positions of danger. See INHALER.

Fig. 3081.



Fencing-Mask.

2. (*Fortification.*) A cover of gabions or earth to protect workmen in constructing a battery; or a screen for a battery.

Masked Bat'ter-y. (*Fortification.*) A battery concealed from the view of the enemy by mantlets, bushes, or other screen.

Ma'son-ry. The art of so arranging stones or brick as to produce a regular construction.

The masonry of the ancient Egyptians was remarkable for the large size of the stones employed, sometimes as much as thirty feet in length. They were laid without mortar.

The Cyclopean or earlier masonry of the Greeks, some remains of which exist in the walls of Mycenæ and Tiryns, was formed of large and irregularly shaped masses of stone, the interstices being filled with smaller stones. Tyrrhenian or Etrusean masonry is also composed of similar stones, but so fitted together as not to admit of smaller stones between them. The more ancient remains of Greece and Italy afford examples of this kind of masonry. Peru also affords remarkable instances of cyclopean masonry.

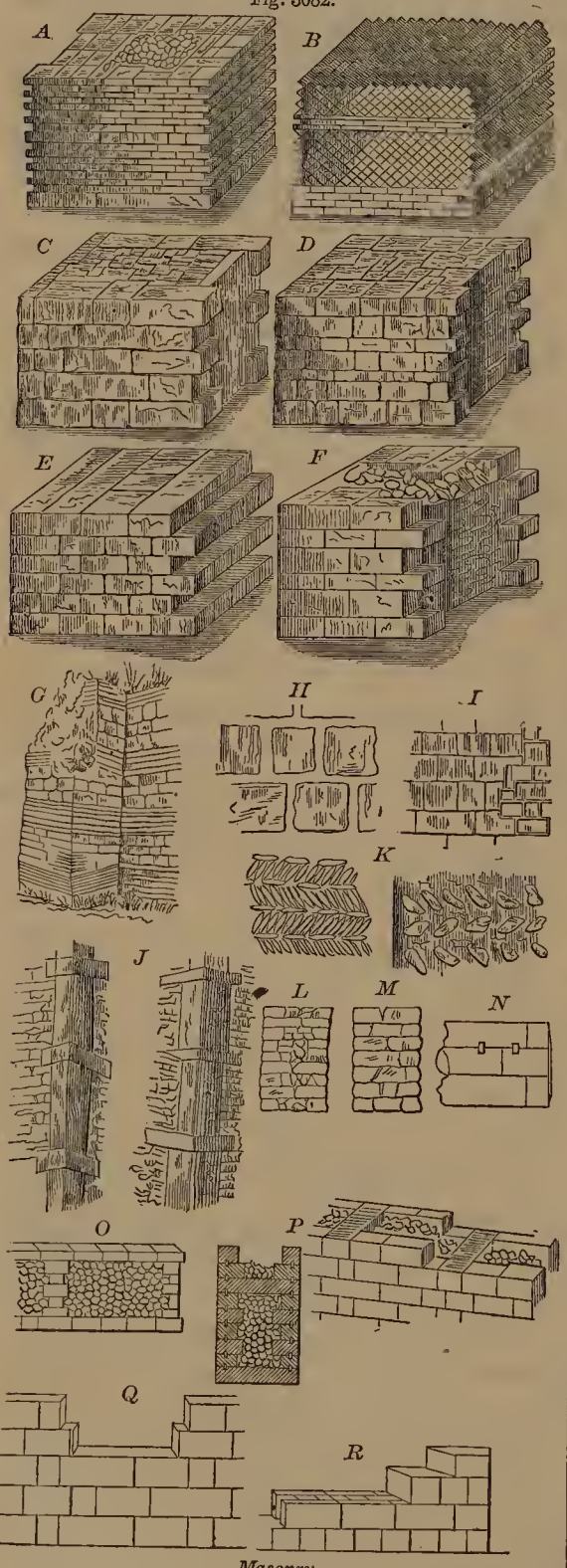
To this succeeded the practice of making the beds horizontal or nearly so, but the vertical joints were irregular. All the preceding were laid without mortar. The Phœnician ashlar masonry is known by its bevel, and the specimens uncovered at Jerusalem are of surpassing interest.

The Greeks and Romans used several methods for walling, as the *opus incertum*, *A*, Fig. 3082; *B*, *opus reticulatum*, formed of square stones laid diagonally; *C*, *isodomon*, in which the courses were of equal hight; *D*, *pseudisodomon*, in which they were unequal; *E*, Greek *emplectum*; *F*, Roman *emplectum*, of coursed work on the outside, the interior being of rubble. In these the stones were small and laid in mortar. Where large stones were used, no mortar was employed. The Roman emplectum found in England has sometimes courses of tiles built in, as shown at *G*. *H* represents wide-jointed masonry, and *I* a combination of wide and close joints.

In a few of the earlier English buildings, considered by some to be Saxon, the quoins, the door and win-

dow jambs, and occasionally some other parts, were formed of stones alternately laid flat and set up endwise; the latter were usually much longer than the others. This is termed *long and short work* (*J*).

Fig. 3082.



Masonry.

In the Norman period, *herring-bone work* (*K*) was frequently employed in rubble walls.

The stones used during the Middle Ages were seldom larger than could be lifted by two or three men.

The various kinds of masonry employed in modern practice may be divided into three principal classes:

Rubble work (*L*), in which the stones are not squared.

Coursed work (*M*), in which the stones are squared more or less and set in courses.

Ashlar (*N*), when each stone is squared and dressed to given dimensions.

O, rubble with cut-stone plinth, quoins, piers, and coping.

P, ashlar facing filled in with rubble.

Q. The stones of equal thickness laid alternately header and stretcher. The length of each stone is double its width.

R, a kind of masonry met with in Italy, composed of alternate courses of headers and stretchers.

The following are some of the technical terms employed to designate various species of mason-work.

Dressing is the working on the faces and beds.

Plane-ashlar; rubbed smooth.

Hammer-dressed; squared and picked by the hammer.

Broached; hewn by mallet and chisel.

Tooled or *drove;* the surface worked in parallel flutes.

Random-tooled; the tooling irregular.

Boasted or *chiseled;* wrought by a narrow chisel.

Nigged; dressed with a pick or pointed hammer.

Rough; axed on the face.

Rubble; a filling in with irregular stone.

Bowlder; made up of rounded unwrought stones.

Parpoint; squared stones laid in courses, with courses of *headers* at intervals of say five feet.

The largest stones ever placed in a wall by the hand of man are probably those in the foundations of the west and north sides of the temple of Baalbek. Thompson says: —

Fig. 3083.

Stone at Baalbek.

"The first tier above ground consists of stones of different lengths, but all above 12 feet thick and the same in width. Then come three stones, each more than 63 feet long. One of them lies in the quarry, where it can be viewed all round and measured easily. It is 14 × 16 and 69 feet long. It is 1½ miles distant from the temple." The stones are so well squared and jointed that it is difficult to find the crack, which indeed will not admit the blade of a knife. Dr. Thompson states he quite overlooked it at first, and supposed the stone to be 120 feet long.

The foundation is much older than the Greek temple which was built upon it and occupies a portion only of the area. The stones of the former building are believed to have been cut up to form the shafts, capitals, etc., of the Corinthian temple subsequently built. The original was probably the work of that great Asiatic nation of which the Phœnician people was an outlying branch, and possibly Arabia the home.

Ma'son's and Brick'lay-er's Tools and Work.

Abaciscus.
Abamurus.
Abreuvoir.
Abutment.
Acisculus.
Aiguille.
Alabaster.
Amandola.
Ancon.
Arch.
Archivolt.
Ashlar.
Assize.
Backer.
Backing.
Badigeon.
Bauker.
Barge course.
Bari.
Barrel vault.
Bat.
Batter.
Beam-filling.
Bed.
Bedding-stone.
Belt.
Béton.
Blocking-course.
Blue turquin.
Boaster.
Boasting-chisel.
Bond.
Bond-stone.
Bond-timber.
Border-stone.
Boss.
Bossage.
Bow.
Bowlder-wall.
Breast-wall.
Breccia.
Brick-axe.
Bricklayer's hammer.
Brick-nogging.
Brick-trimmer.
Bridge-stone.
Broad-stone.
Brocatelle.
Burin.
Bush-hammer.
Camber-slip.
Cantilever.
Cement.
Chain-bond.
Chamfretiug
Channeling-machine.
Channel-iron.
Charring-chisel.
Chisel in marteline.
Ciborium.
Ciper-tunnel.
Civery.
Clinker.
Closer.
Clustered arch.
Cob-wall.
Coffer-work.
Columbaria.
Commissure.
Concrete.
Coping.
Corbel.
Corbel-table.
Cordon.
Counter-fort.
Countermure.
Counter-vault.
Countess.
Course.
Coursed masonry.
Coursed-rubble masonry.
Coussinet.
Cover.
Coving.
Creasing.
Crest-tile.
Cresting.
Cross-bond.
Cross-springer.
Crypt.
Curb.
Cushion.
Cut-splay.
Cut-stone.
Dead-flue.
Dead-wall.
Diatoni.
Discharging-arch.
Dog's-tooth.
Dook.
Door-stone.
Dove.
Dovetailing.
Draft.
Dressings.
Drip-stone.
Drum-curb.
Dry arch
Dwarf-wall.
Earth-table.
Embattled.
Embrasure.
Emplectum.
Extrados.
Face-guard.
Feather.
Fireplace.
Fire-proof structure.
Flag-stone.
Flat-band.
Flint-wall.
Float-stone.
Footing.
Fraise.
Gable.
Gaged-rib.
Galets.
Garreting.
Gavel.
Geostatic arch
Grading.
Grouting.
Hacking.
Hack-barrow.
Handsaw.
Hanging-buttress.
Header.
Heading-course.
Heart-bond.
Herring-bone.
Hewn-stone.
Hod.
Holing.
Hook-tool.
Houguette.
Hydraulic cement.
Hydraulic lime.
Hydrostatic arch.
Impost.
Incertum.
Incrustation.
Incrusted
Intrados.
Invert.
Inverted arch.
Isodomon.
Jack-arch.
Jamb.
Jasper.
Joggle.
Jointer.
Jointing-rule.
Kevel.
Keystone.
Kiush.
Knapping-hammer.
Kuobbing.
Lagging.
Lapis lazuli.
Later.
Ledgement.
Ledger.
Level.
Lewis.
Liernes.
Line-pin.
Liner.
Lockrand.
Lunette.
Lutheran.
Lychnoscope.
Mallet.
Mantel.
Marble. Artificial
Marble-cement.
Marble-grinding machine.
Marbleizing slate.
Marble-polishing machine.
Marble relief-work.
Marbles. Playing
Marble-worker's files.
Marble-working.
Marcus.
Marmoratum.
Marteline chisel.
Marteline hammer.
Martin.
Masonry.
Matrix.
Moellon.
Monolith.
Mortar.
Mortar-tempering machiue.
Mullion.
Nigged ashlar.
Nog.
Obelisk.
Off-set.
Opus.
Paros marble.
Parpoiut-work.
Parting-tool.
Party-wall.
Perbend.
Pick-hammer.
Piel.
Pietra dura.
Pinning-in.
Pisé work.
Pitch.
Pitched work.
Plaster.
Plinth.
Plug and feather.
Plumb.
Point.
Pointer.
Pointing.
Porphyry.
Poyntel.
Pozzuolana.
Protean-stone
Pseudisodomon.
Pudding-stoue.
Pugging.
Puncheon.
Put-log.
Quarrel.
Quarrying.
Qnoin.
Raker.
Raking-piece.
Regrating.
Relieving-arch.
Reredos.
Retaining-wall.
Reticulated wall.
Reticulatum.
Reveal.
Revetment.
Ridge-tile.
Ripper.
Ripping-bed.
Rip-rap.
Rock-drill.
Rough-cut.
Round-nose chisel.
Rubbing-stone.
Rubble masonry.
Runner.
Rustication.
Rustic quoin.
Rustic work.
Saddle-back.
Sagitta.
Scabbling-hammer.
Scagliola.
Scantling.
Scapple.
Scarcement.
Scraper.
Screw-plate
Segmental arch.
Semicircular arch.
Serpentine.
Set-off.
Severy.
Skew.
Skew-back.
Skiffliug.
Slab.
Slate.
Slate-cutter.
Slate-making machine.
Slate-pencil.
Slate-trimming machine.
Slatt.
Slushed.
Soffit.
Spall.
Span.
Spandrel.
Spandrel-wall.
Spire.
Springiug.
Square.
Squinch.
Stabbing.
Steening.
Stercostatic arch.
Stouc. Artificial
Stone-axe.
Stone-boat.
Stonc-breaker.
Stonc-breaker's hammer.
Stone-bridge.
Stone-channeling machine.
Stone-crusher.
Stone-cutting.
Stone-dressing machine.
Stone-drilling machiue.
Stone-gatherer.
Stone-grinding machine.
Stone-hammer.
Stone-molding machine.
Stone-polishing machine.
Stone-preserving.
Stone-saw.
Stone-vessel.
Stoneware.
Straggling.
Straight-arch.
Stretcher.
Stretching-course.
Striug-course.
Stucco.
Summer.
Terrasse.
Tesselated pavement.
Testing-machine.
Throat.
Through-stone.
Tie-wall.
Tile.
Tile-creasing.
Tile-machine.
Tin-saw.
Tooling.
Toothing.
Trapezoidal wall.
Trass.
Travertine.
Underpinning.
Undersetting.
Vault.
Vault-cover.
Vault-light.
Veneering-marble.
Vise.
Voussoir.
Water-table.
Wall.
Wing-wall.
Withe.
Wood-brick.
Worm.

Ma'son's-lev'el. A plummet-level.

Mas'si-cot. (*Glass.*) The manufacturer's name for the protoxide of lead used in making flint-glass.

Mas-sool'a-boat. (*Nautical.*) A boat of the Coromandel coast, adapted to be beached on the surf-beaten shore. The planks are sewed together with coir, over wads of coir which press upon the seams. They are 30 to 35 feet long, 10 to 11 feet beam, 7 to 8 feet deep, and are rowed by 12 men,

oars double-banked, and a steersman with an oar at the stern.

Mast. (*Nautical.*) A long spar placed amidship, nearly perpendicularly upon the keelson, and serving to support the yards and gaffs to which the sails are bent.

Masts are known by a variety of terms which define their position or relation.

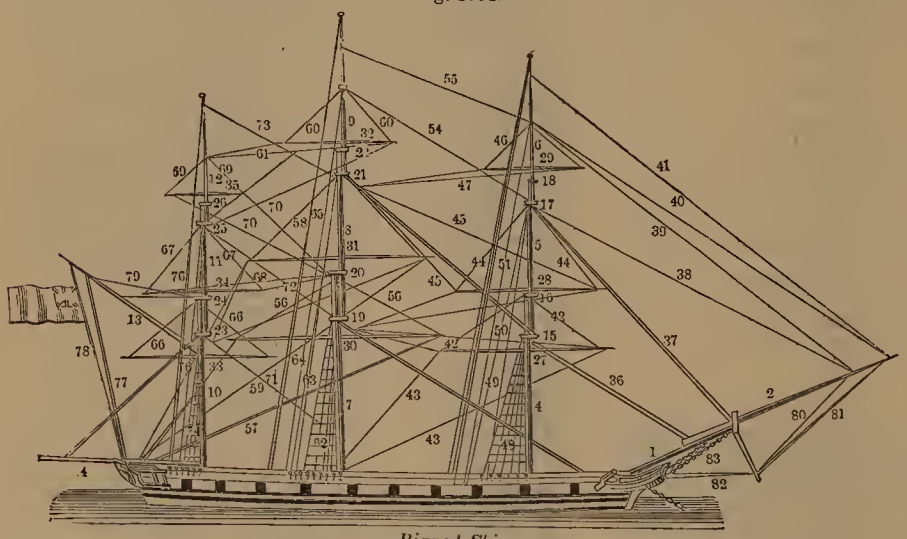
A mast consisting of one piece is a *pole-mast.*

Masts are also known as *single-tree* masts or *made* masts.

Masts for large vessels are composed of several pieces, about 1 foot square, with rounded segmental lengths on the outside, and the whole encircled at intervals by hoops. The middle tree is the spindle. The *fishes* are the side-trees.

With *two* masts: the larger is the *main*-mast, the smaller is the *fore*-mast or the *mizzen*-mast, according to its position relatively to the main-mast.

Fig. 3084.



Rigged Ship.

This rule is thus stated by the authorities, but is not always adhered to in practice.

Brigs, by this rule, have *fore* and *main* masts.

The *ketch*, *brigantine*, and *schooner* have *main* and *mizzen* masts.

With three masts: they are called *fore*, *main*, *mizzen.*

With four masts: they are called *fore*, *main*, *main-mizzen*, *bonaventure-mizzen.*

The proportions of the different masts to each other are about as, —

Mizzen, 7; main, 10; fore, 9.

The portions of a mast consisting of several spars are termed, —

The *lower-mast*, *top-mast*, *top-gallant mast*, *royal-mast.*

The hight of a lower-mast has three subdivisions:

The *housing*; from the heel to the upper deck.

The *hounding*; from the deck to the *hounds.*

The *head*; from the hounds to the cap.

The *heel* of a mast is its lower end, and rests in the *step* on the *keelson.*

At the deck it is supported by *earlings* and *beams.*

Above the deck are cleats called *partners*, which form a rim around the deck-opening.

At the *hounds* the rigging is secured to the mast. The mast is stayed by *fore-stays*, *back-stays*, and *shrouds.*

The *head* is the portion to which the lower end of the topmast is secured.

The *cap* is the block at the head of a mast, which forms a yoke for the attachment of the upper mast thereto.

The *hounds* are cheeks supporting the *trestle-trees.*

The *trestle-trees* are fore and aft timbers to support the *top.*

The *cross-trees* are timbers lying athwartship and scored down upon the *trestle-trees.*

The *top* is a flat platform to spread the shrouds of the upper mast, and for other purposes.

On the sides of the *top* are *futtock-plates*, having holes through which pass the *futtock-shrouds*, whose lower ends are secured to the chain-necklaces on the mast below the hounds.

The *fid* is a transverse key passing through the heel of the topmast and resting on the *trestle-trees.*

Iron masts are made hollow, the plates of the shell being single-riveted at the longitudinal joints and double-riveted at the circular joints. Internal stiffening ribs and braces prevent flexure, collapse, or torsion.

Tripod masts, invented by Captain Coles, English Navy, have three diverging legs, and obviate the use of standing rigging.

A *trysail*-mast is a small mast abaft the mizzen to carry a gaff.

A *spencer*-mast is a similar spar, abaft the *fore* or the *main* mast.

A *jigger* is a small mast, erected on the stern of a *yawl*, a vessel whose rig in other respects is that of a *cutter.*

Fig. 3084 shows the various spars and the most important ropes of a full-rigged ship.

1, bowsprit.
2, jib-boom and flying-jib boom.
3, martingale-boom.
4, fore-mast.
5, fore-topmast.
6, fore topgallant and royal mast.
7, main-mast.
8, main-topmast.
9, main topgallant and royal mast.
10, mizzen-mast.
11, mizzen-topmast.
12, mizzen topgallant and royal mast.
13, spanker-gaff.
14, spanker-boom.
15, fore-mast trestle-trees.
16, fore-mast cap.
17, fore-topmast trestle-trees.
18, fore-topmast cap.
19, main-mast trestle-trees.
20, main-mast cap.
21, main-topmast trestle-trees.
22, main-topmast cap.
23, mizzen-mast trestle-trees.
24, mizzen-mast cap.
25, mizzen-topmast trestle-trees.
26, mizzen-topmast cap.
27, fore-yard.
28, fore-topsail yard.
29, fore-topgallant yard.
30, main-yard.
31, main-topsail yard.
32, main-topgallant yard.
33, cross-jack yard.
34, mizzen-topsail yard.
35, mizzen-topgallant yard.
36, forestay.
37, fore-topmast stay.
38, jib-stay.
39, fore-topgallant stay.
40, flying-jib stay.
41, fore-royal stay.
42, fore-lifts.
43, fore-braces.
44, fore-topsail lifts.
45, fore-topsail braces.
46, fore-topgallant lifts.
47, fore-topgallant braces.
48, fore-rigging.
49, fore-topmast backstays.
50, fore-topgallant backstays.
51, fore-royal backstays.
52, main-stay.
53, main-topmast stay.
54, main-topgallant stay.
55, main-royal stay.
56, main-lifts.
57, main-braces.
58, main-topsail lifts.
59, main-topsail braces.
60, main-topgallant lifts.
61, main-topgallant braces.
62, main-rigging.
63, main-topmast backstays.
64, main-topgallant backstays.
65, main-royal backstays.
66, cross-jack lifts.
67, mizzen-topsail lifts.
68, mizzen-topsail braces.
69, mizzen-topgallant lifts.
70, mizzen-topgallant braces.

71, mizzen-stay.
72, mizzen-topmast stay.
73, mizzen-royal stay.
74, mizzen-shrouds.
76, mizzen-topmast backstays.
76, mizzen-royal backstays.
77, spanker-vangs.
78, ensign-halliards.
79, spanker-peak halliards.
80, jib-boom martingale-stay.
81, flying jib-boom martingale-stay.
82, martingale back-ropes.
83, bobstays.

Guppy's mast, English patent, 1826, consisted, instead of a single pole or spar, of a pair of spars stepped into the ends of the beams and uniting at the crosstrees, forming an isosceles triangle. Being hinged at the deck, they were designed to be lowered fore and aft, depending for their stability in use upon the stays.

Shuldham's revolving mast (English patent) is capable of rotation, so as to present the sails in the required direction by rotation on its axis, instead of veering the yards.

Here, as in regard to many other subjects, the Greeks credit Dædalus with the first invention. How many centuries previously the rivers of China, the Ganges, and the Nile had been dotted with sailing craft, it is impossible to say. 'A part of the corn which Joseph collected was probably brought in sailing-vessels to the depot, over 400 years before the date of the Athenian mechanic.

Icarus, says Pliny, was the person who invented sails, and Dædalus the mast and yards.

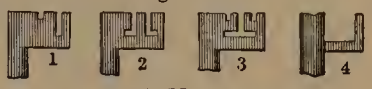
The ships of antiquity depended more upon rowers than sails, but were provided with masts and sails as accessories. Upon the Nile, the barges were propelled by sails generally, excepting that numerous class which partook of the character of rafts, were floated down the river, carrying produce, and were not returned up stream. One mast and one sail, the latter depending from a yard, is the general feature, though a plurality of masts was not uncommon, especially with large vessels, such as the galley built by Archimedes for Hiero of Syracuse. It had 3 decks, towers on the bulwarks, stables, libraries, baths, fish-ponds, a crew of 600 men, and a main-mast that came from England. This was about 240 B. C. (See SHIP.) Syracuse was captured by Marcellus 212, and Archimedes slain. The mast is presumed to have been brought by the Phœnician or Carthaginian navigators from England, as those maritime nations were yet in existence. Poor Tyre had been desolated by Alexander 100 years before, but the people dispersed around the Mediterranean were yet active, and Carthage had not fallen before her imperial rival, remorseless Rome.

In the time of Isaiah the masts were strengthened with shrouds from the deck or bulwarks. A few years later we read that the Tyrians obtained cedar masts from Lebanon, as no doubt they had been doing for 1,000 years before Ezekiel wrote. The planking of the vessels was "fir-trees of Senir" (Hermon), calked by men of Gebal; the oars of oak from Bashan; the rowers' benches of ivory from the "Isles of Chittim" (some western land on the African coast). The sails were fine linen of Egypt, the awnings of purple and blue fabric "from the Isles of Elishah." Josephus identifies the descendants of Elishah, the eldest son of Javan, with the Æolians. So Greece furnished the Tyrian dye. Lydia of Thyatira, a seller of purple, was converted A. D. 53, under the preaching of Paul of Tarsus. This was in or near the ancient Æolia, so that the local profession was yet preserved.

Mast-car'ling. (*Shipbuilding.*) Large timbers at the side of the mast-rooms that are left deep enough to receive the cross-chocks.

Mas'ter-key. A key which commands many locks of a certain set, the keys of which are not interchangeable among themselves. While neither one of a series of keys may suffice to open any lock besides the one for which it was constructed, a master-key is one which may operate any one of the set. In the annexed series, the key No. 4 is master of the locks for which the keys Nos. 1, 2, and 3 are specially constructed.

Fig. 3085.



(*No.* 4) *Master-Key.*

Mas'ter-tap. A *tap-screw.*

Mas'ter-wheel. The main wheel in a machine which acts as a driver of many parts. Such is the large cog-wheel in a horse-power which imparts motion to a circular system of pinions. See HORSE-POWER.

Mast-hole. (*Shipbuilding.*) A hole in the deck to receive a *mast.* It is of larger diameter than the mast by double the thickness of the wedges which hold the mast in position.

The framing of the mast-hole consists of *fore-and-aft partners, cross-partners,* and *corner-chocks.*

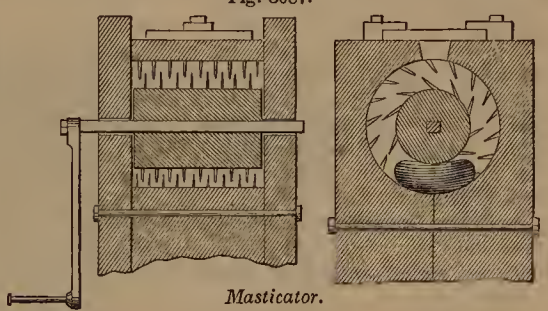
Mast-hoop. A circular band to which the luff of a fore-and-aft sail is bent, and which slips on a spar in raising and lowering. In the example, the hoop is composed partly of wood and partly of metal, the metallic portion being provided with friction rollers.

Fig. 3086.

Mast-Hoop.

Mas'ti-ca-tor. 1. A small machine to cut up meat for aged persons or those who have lost their teeth or the power of chewing. It is screwed to the table; the food is fed in at the top, and a crank to which a number of sharp knives are attached is turned in opposition to a number of stationary ones. This minces the food, and deposits it on the plate of the person. Food cut up in this manner retains all the nourishing qualities. The interior

Fig. 3087.



Masticator.

of this machine is lined with porcelain, and is easily kept clean. See MEAT-CHOPPER; MEAT-CUTTER; SAUSAGE-MACHINE.

2. The machine which kneads the raw caoutchouc to render it homogeneous.

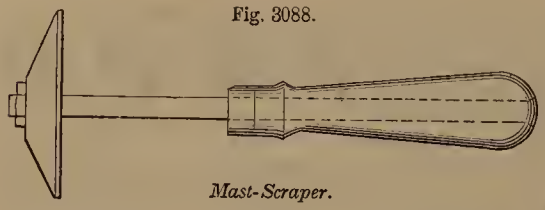
Mast'ing-shears. A hoisting device consisting of two spars and one or more guys, used to elevate masts on end to put them in position aboard vessels, or remove them from vessels. See SHEARS.

Mast-prop. A spar forming a lateral support for a mast when a ship is careened.

Mast-scrap'er. A tool for scraping masts; it is usually a triangular plate with an edge whose bevel is away from the handle. Its edge is sometimes partly concave, to more nearly fit the contour of the mast.

Mast-step. A socket at the foot of a mast.

Fig. 3088.



Mast-Scraper.

Mast-tack'le. (*Nautical.*) *a.* Purchases used in putting up or sending down masts.

b. Purchases attached to the mast for lifting or lowering boats, getting in freight or stock, bulky stores, machinery, blubber, etc.

Mast-trunk. (*Nautical.*) A box, in small vessels, in which stands the mast.

Mat. 1. (*Nautical.*) A wad of woven or thrummed junk. Used to secure standing rigging from the friction of yards and ropes.

2. (*Domestic.*) *a.* A rug of straw, rushes, husks, coir, junk, hemp; a tufted fabric of these materials or of wool; a skin with the hair or wool on; a set of slats, etc. Mats are for cleaning shoes at a door; keeping the feet from a cold floor, as in cars or halls, and elsewhere; covering up plants against frost, etc.

b. A small piece of oil-cloth, fabric, or worsted work, to place beneath a hot dish or wet pitcher, to preserve the polish of a table.

3. (*Photography.*) An ornamental plate or passe-partout laid over a daguerreotype, etc., and forming an oval or other symmetrical border to the picture, as well as keeping the plate from abrasion by the glass.

4. (*Metallurgy.*) An alloy of metals in a crude form, in the process of reducing. *Matt, matte.*

Match. 1. A splint or strip of combustible material, usually wood, one end of which is dipped in a composition that ignites by friction.

The earliest and most primitive way of obtaining fire by artificial means seems to have been that still in use among the South-Sea-Islanders and other savage tribes, by rubbing two sticks of dry wood together. To this succeeded the flint, steel, and tinder-box, and to them various forms of friction-matches and chemical devices.

The word "matches" recalls to our memory the slips of pine with their ends pointed and dipped in brimstone. This was the old associate of the tinder-box, with its flint and steel, of which the rising generation knows nothing. A *match* now means a little square or round splint dipped in a composition which explodes by friction, and renders the flint, steel, and tinder unnecessary. There were several steps in the progress from one system to the other, as we shall see. For a description of a series of inventions which preceded *matches*, see LIGHTING-DEVICES.

About 1820, the first attempt may be said to have originated to dispossess the old flint and steel dynasty, though as long ago as 1677 the German chemist Krafft had indicated the uses of phosphorus for procuring light or fire. Boyle, at this period, describes it as "a factitious, self-shining substance," procurable in small quantities at great expenditure of time and labor. In 1680, Godfrey Hanckwitz, at his laboratory in Southampton Street, London, manufactured and sold large quantities of phosphorus for the purpose of striking light.

About 1825, the hydrogen-lamp was invented by Dobereiner, a German, and was long in favor. It consisted of a piece of spongy platinum, which was rendered incandescent by the passage of hydrogen. See HYDROGEN-LAMP.

About the same time we hear of a composition of phosphorus and sulphur placed in a vial, and used by dipping a match and then rubbing the composition on the cork to excite ignition.

Then followed the match dipped successively in sulphur and then in a mixture of sugar and chlorate of potash. These were lighted by dipping in sulphuric acid.

The "Promethean" matches were made of a roll of paper treated with sugar and chlorate of potash and a small cell containing sulphuric acid. This cell was broken with a pair of pliers, and the acid ignited the composition by contact therewith.

Next (about 1834) we find the "Lucifers," which were coated with a mixture of sulphide of antimony and chlorate of potash made into a paste with gum-water, and ignited by drawing between the surfaces a folded piece of sand-paper.

The "Congreve" next appeared, in which phosphorus was substituted for sulphide of antimony.

In March, 1842, Reuben Partridge patented a machine for making splints.

1845, Schrötter of Vienna discovered amorphous or allotropic phosphorus, which rendered the manufacture less unhealthy, and the matches less dangerous.

The process of manufacture is, according to Tomlinson, as follows: —

Thick pine planks are cut into blocks by a circular saw, and these are divided into splints by a series of lancets in a reciprocating frame, which score the face of the block to a certain depth. A scythe-shaped knife, cutting the whole width of the block, then swings round and severs the row of splints. This produces square matches.

Circular matches are made by pressing the block against a plate having circular perforations, the interspaces between which are beveled so as to form cutting edges.

As the splints fall from the cutting-machine they pass down a shoot into an apartment below, where they are tied up in bundles of half a gross, after which they are dried in a hot room.

Each end of the bundle is next dipped in a pot of melted sulphur, and another string is tied around it, so that when divided by the circular saw two complete bundles are formed. They are now dipped in the phosphorus composition, the ingredients of which vary somewhat among different manufacturers, but consist essentially of nearly equal proportions of phosphorus, glue or gum, and fine sand (whiting is preferable), with coloring matter added, the whole mixed with water. Heat is applied in incorporating the materials, and the vessel containing them is maintained at a temperature of 98° in a water-bath. The composition is spread on a steam-heated slab. The matches are prepared for dipping by inserting them singly in a perforated frame containing fifty matches, from which each end of the splint projects. A boy then takes each frame and presses the ends of the matches upon the composition on the slab. They are next dried and boxed, which latter operation is performed, at the rate of 3,000 boxes per day, by little girls. Since the above was written more expeditious methods have been adopted.

The modes of operation in the United States differ somewhat in different establishments. The whole work is, however, done by machinery.

By one mode the splints are cut by a small machine containing 12 circular cutters, and carried by an endless chain 200 feet long, the sides of which are grooved to hold them to the sulphur-bath, imperfect splints being dislodged on the passage by the upward blow of a small hammer.

A wheel, revolving in the bath of molten sulphur, gives their ends a coating as they pass, after which they are carried 40 or 50 feet farther, where a similar

wheel touches their ends with phosphorus. They are carried by the chain about an equal distance onward, where the chain passes over a wheel, descending perpendicularly to the trays for receiving the matches, which, as they arrive, are pushed from the chain by a slider, and received in the trays.

Eight of these machines make 800 gross, 14,400 each, of matches daily. 600,000 feet of pine lumber, 250,000 feet of bass-wood for packing-cases, 300 barrels of brimstone, and 9,000 pounds of phosphorus are annually consumed.

Making the splints is in general a separate branch of the manufacture, as they can be made cheaper by machinery on a larger scale. See MATCH-SPLINT MACHINE.

A factory in New York State uses annually 720,000 feet of pine for matches, and 400,000 feet of bass-wood (linn) for cases; of sulphur 400 barrels, and phosphorus 9,000 pounds. The daily consumption of paper is 500 pounds, and of pasteboard for large boxes 8,000 pounds weekly. The daily consumption of paste is produced from 66 pounds of flour, and the one cent stamps used daily foot up the amount of $1,440.

Some matches are made without sulphur, thus avoiding the offensive smell of that mineral. A German composition for this purpose consists of phosphorus, 4 parts; water, 10; fine glue, 6; red ocher or red lead, 5; smalt, 2. The ingredients, in the order named, are incorporated with the liquefied glue to form a paste.

The ends of the splints are, in some cases, dipped in paraffine, to secure more ready ignition.

It has been proposed to employ sodium instead of phosphorus in the manufacture of matches. It ignites as easily, and is free from offensive odors.

A scientific journal strongly deprecates the idea, and cautions the public against the use, as sodium is so readily oxidized as to burn when wetted.

2. (*Ordnance and Mining.*) A *slow*-match consists of loosely twisted hempen cord dipped in a solution of saltpeter and lime-water. It burns at the rate of one yard in three hours.

A *quick-match* is cotton coated with a composition of mealed powder, gum, and water. When not confined it burns at the rate of one yard in thirteen seconds.

Another *quick-match* is made of cotton-wick boiled in saltpeter and water. Alcohol is added to the warm solution; mealed powder is added, and the wick left to steep for 24 hours. The match is then dried.

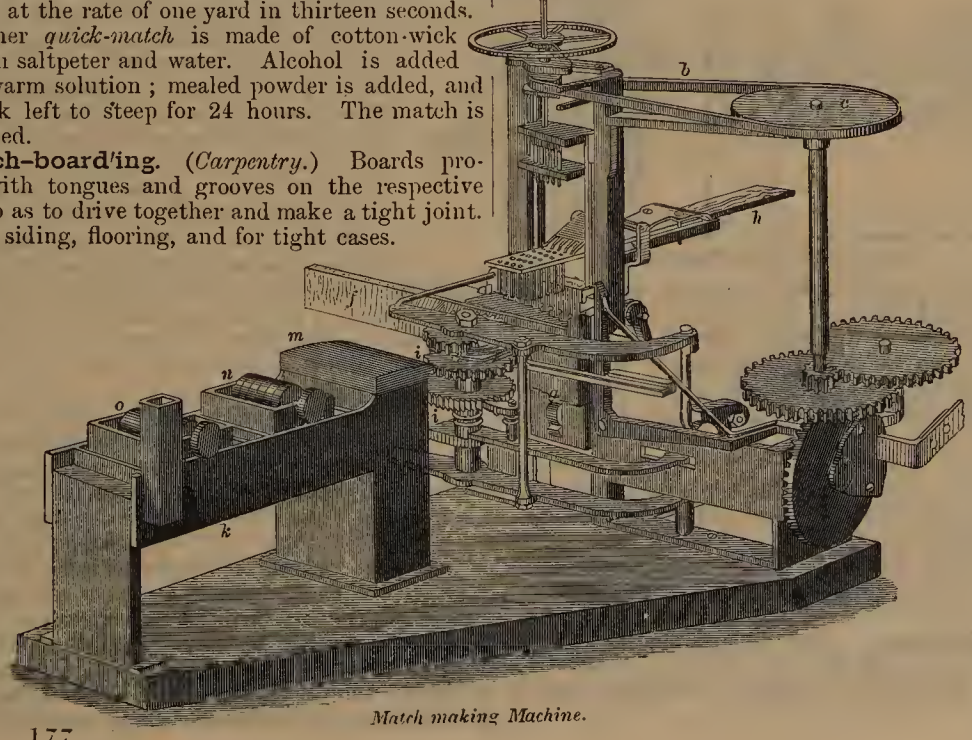
Match-board'ing. (*Carpentry.*) Boards provided with tongues and grooves on the respective edges, so as to drive together and make a tight joint. Used in siding, flooring, and for tight cases.

Match-box Ma-chine'. In Poirier's machine the boxes are made of pasteboard, which is cut into pieces each of suitable size to make the body or the top of a box. These pieces are rectangular in form, but are rounded at the angles. They are introduced one by one into the machine, and are instantly forced by a plunger into a box-shaped matrix or socket, where they receive at one movement the form desired. In this operation the corners, in which the material is in excess, are folded over on the sides, and an energetic pressure is exerted on the folds by means of four cams; in consequence of which these folds become compacted into one mass with the sides of the box. The capacity is 3,000 per hour.

Match-cloth. (*Fabric.*) A coarse woolen cloth.

Match-dip'ping Ma-chine'. Schmidt's match-dipping machine at the Paris Exposition was arranged for dipping 6,000 matches in four minutes. The splints, properly cut and prepared, are received upon a horizontal plate or table grooved to the size of the matches, and are made to fall into the grooves by the action of a broad brush which is suspended above the table, and which the operator moves by means of a pedal. In front of the table on which the matches thus arranged lie, is a frame placed vertically, which is designed to receive a number of layers of matches, one above another. This frame presents immediately before the row of matches a narrow receiving-plate or bed. By the action of a second pedal the workman causes a row of needles to advance, which push forward the matches on to this plate, and are retracted by a spring. The matches are pushed beyond the edge of the receiving-plate just so far as may suffice for dipping, and their ends are kept separate by thin partitions, which are a fixed part of the machine. The frame, which has a movement up and down in guides, is then depressed sufficiently to permit another receiving-plate to be laid on the last row of matches, at a proper level to receive an additional row; and this process goes on until sixty rows, each containing one hundred matches, have been piled up in the frame. The frame is then locked up by bringing down a traverse

Fig. 3089.



Match making Machine.

bar at the top, so as to compress the whole mass and secure it in place. The matches are thus confined as in a printer's chase. They are then evened at their end like type, and are ready for dipping. — *Dr. Barnard's Report Paris Exposition.*

Match-gear'ing. (*Gearing.*) Two cog-wheels of equal diameter geared together.

Match-hook. A double hook or pair of hooks in which one portion forms a *mousing* for the other.

Match'ing-ma-chine'. A wood-planing machine which tongues and grooves the respective edges of a board. See MOLDING-MACHINE.

Match'ing-plane. See MATCH-PLANE.

Match-lock. The form of gun-lock which preceded the wheel-lock and the flint-lock. It had a match, whence its name, which was presented to the priming. Still used in some parts of Asia. See REVOLVER.

Match-mak'ing Ma-chine'. Young's match-machine cuts the splints from a block or bolt of wood, sticks them singly in a strip of thin board, and passes them, points downward, over a trough or vat containing the chemicals, which are applied and the matches completed before the strip leaves the machine.

Fig. 3089 shows Young's machine. A gate carries a set of boring bits above and as many cutters *g* below. The bits are geared to run together at uniform speed, and are driven by belt *b* from pulley *c*. These bits are to bore holes in the strip *h*, into which all the matches are stuck as soon as cut from bolt *f*. *i i* are feed-wheels to bring the bolt of match timber to the cutters. *k* is a steam-chamber to heat chemicals and char the end of the splints as they pass over the block *m*, and *n o* are cylinders which apply chemicals to the splints as they pass.

The gate which carries cutters and bits being drawn up, the block is fed under the knives, which, in their descent, cut square splints from the block. The strip of board is then fed

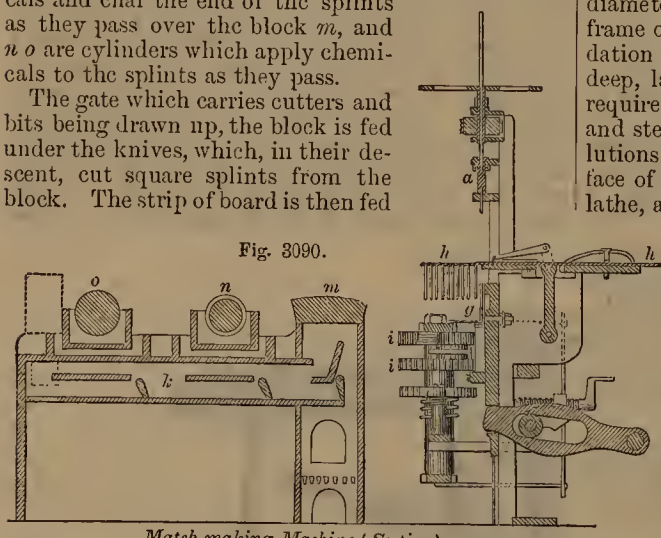


Fig. 3090.

Match-making Machine (Section).

under the bits and over these newly cut splints. The bits bore a hole for each splint, then retreat, and by the farther descent of the gate the ends of the splints are forced into their respective holes in the slip *h*. The farther progress of the slip applies the chemicals, the slip advancing one row of matches to each descent of gate.

After the matches have been completed by the machine and dried a suitable time, they can be removed from the strips of wood and packed in boxes, or they may be sold adhering to their backing, in which condition they are known as *block matches.*

Fig. 3090 is a transverse section of the same machine.

Match-planes. A pair of planes making a tongue and groove respectively, the former to fit the latter. Used in making tight joints on meeting edges of boards.

Adjustable match-planes have moving fences to determine the distance of the tongue or the groove from the working edges of the respective boards. For varying widths of grooves and tongues different *irons* are used.

Fig. 3091.

Match-Joint.

Match-plate. (*Founding.*) A plate upon the opposite sides of which the halves of a pattern are placed correspondingly, to facilitate the operation of molding. The plate is placed between the parts of a flask, rammed up from both sides, and removed, allowing the parts to come together.

Match-safe. A box to contain matches for use. Usually hung up near a gas-bracket or elsewhere within ready reach.

Match-splint Ma-chine'. Matches of cylindrical form have been made by compressing the quadrangular slips or drawing the wood through holes in a draw-plate. The Austrian circular matches are cut from planks of clean grained wood, by means of hand-planes carrying a series of steel tubes, which produce long, thin splints of wood of circular section. These are afterward cut into lengths.

In Rimailho's machine the block of wood is the length of the match. The machine has a slide carrying a series of tubes made out of a solid piece of steel and kept sharp at their edges; a frame keeps the wood in contact with the tool. The slide is moved rapidly backward and forward by an eccentric, and cuts a row of matches at each stroke, each fresh row throwing out those previously made.

De Bowen's machine consists of a wheel 20 feet in diameter, and 6 feet across the face, supported on a frame of heavy timbers, and resting on a stone foundation 25 × 12 feet in length and width, and 5½ feet deep, laid in cement. This ponderous foundation is required in order to maintain the necessary accuracy and steadiness in the wheel, which makes 21 revolutions per minute. The blocks are clamped to the face of the wheel. A rest, similar to that of an iron lathe, and moved to the right or left in like manner, is placed in front of the breast of the wheel, and carries 16 annular steel cutters. The number of these may be doubled if necessary.

They are adjusted so as to face the blocks, and as the wheel revolves each cuts a splint out of the wood, which drops below. The cutters are advanced forward the exact thickness of a splint at each revolution of the large wheel, until they have cut through the thickness of the blocks, 6, 8, or 10 inches, when they are brought back to their original position by turning a wheel. The cutters are adjusted to cut the splints out of the projections left between the corrugations made by them in the blocks at the preceding revolution of the wheel. It is said that each machine, with 16 cutters, will cut 86,400 sticks per minute, 5,184,000 per hour, or 51,480,000 in a working day of 10 hours.

The sticks fall from the cutters in a shower into a trough below, through which passes a belt that carries them to a series of shakers having latticed bottoms, through which imperfect sticks and pieces of shavings drop. They are then deposited in cases with latticed bottoms and conveyed to the drying-rooms, where the boxes are placed in tiers, three or four deep, upon steam-pipes heated to a temperature of 120°, where they are allowed to remain a day and a night, effectually drying the wood. After drying they are arranged in parallel rows by another series of shakers and packed in boxes. They are then ready for shipment to the manufacturers, who perform the

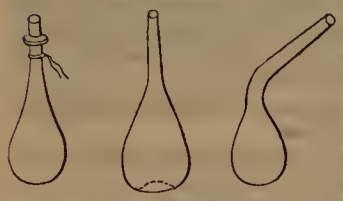
dipping process, that being a separate branch of the manufacture.

Match-tub. A tub about eighteen inches high, in which a slow-match is hung, fire downward.

Match-wheel. A cog-wheel adapted to mesh into or work with another.

Mat'rass. (*Pharmacy.*) A glass vessel with a long neck, a rounded body, and sometimes furnished with a tubulure. It is used for distilling and digesting.

Fig 3092.



Matrasses.

Ma'trix. 1. A mold which gives form to an object driven into it or hardening therein, as, —

a. The intaglio or indented device for a coin, either engraved or produced from a *hub* on which the design has been produced in relief. The *matrix* is the mold into which a soft steel *plug* is driven, and which is to be used in making the *die* from which the coin is struck.

The series is as follows: —

1. The engraved *hub* (cameo).
2. The *matrix* (intaglio).
3. The *punch* (cameo).
4. The *die* (intaglio).
5. The *coin* (cameo). See DIE.

b. A bottom die or *bed.*

c. The *mold* in a type-making machine which gives the form to the letter on the end of the type.

Fig. 3093.

Matrix.

The letter is originally engraved on the end of a piece of steel, which is subsequently hardened, and is called a *punch.* The *punch* is used to impress the *matrix.*

d. The plaster mold (in intaglio) obtained from a form of type, and used to obtain an impression (cameo) in type-metal, known as a STEREOTYPE (which see).

e. A matrix in paper is obtained by dabbing down upon the surface of the type successive sheets of unsized, thin paper, with occasional layers of paste. The dabbing is done by a brush, and thus the paper is forced into every crevice of the type. The matrix is then dried and used similarly to a plaster mold. If intended for a *turtle,* it is bent into cylindrical form before casting the metal upon it. The process is much used in newspaper work.

f. A mold for casting. A shape in which anything is formed.

2. The *gangue* or stony substance in which metalliferous ores are formed, associated, or imbedded.

Matt. 1. (*Metallurgy.*) A mass of imperfectly reduced metal having impurities, mineral and metallic, as in the case of copper. See COPPER-FURNACE.

2. (*Gilding.*) The *dead* or unburnished surface of gold, when the gold-leaf is merely pressed upon the size and is not rubbed with the burnisher. The dead appearance of portions acts as a foil to the lustrous surface over which the burnisher has passed. See GILDING.

Mat'ted-glass. (*Glass.*) A mode of ornamenting glass for windows, in which the surface is covered with a very fusible powder, either opaque, white, or tinted. This being removed in portions, the glass is fired and the composition fixed, giving a bright pattern on a dull ground.

Substantially the same effect is produced by painting the pattern on the glass with an asphaltum varnish, and then etching the surface with hydrofluoric acid.

By a similar process the glass bottles of the chemist have their labels ineffaceably inscribed.

Mat'ter. (*Printing.*) Type composed. It is *live, standing,* or *dead,* according as it is ready for use, awaiting re-use, or ready for distribution.

Mat'ting. 1. Matting is made of hemp, coir (the fiber covering the cocoa-nut), jute; also of rushes, hair, grass, palm-leaves, etc. The India matting is made of a peculiar Oriental grass. Russia matting of *bast* or linden bark. Also of strips of black-walnut or other ornamental wood, with wires passing through them at right angles. The wooden strips are separated by elastic washers made from india-rubber tubing. The matting can be rolled up into a compact form for transportation, and is found to have superior advantages for hallways of tenement-houses, street-cars, reception-rooms of hotels, railway depots, etc.

2. The passepartout over a picture. A *mat.*

3. (*Gilding.*) Covering plates with varnish in gilding on water size.

4. A regular rough lusterless surface.

Mat'ting-loom. (*Weaving.*) One in which slats are introduced into the shed to form the woof.

Mat'ting-tool. (*Metal-working.*) A kind of chasing tool, employed in producing a regular rough surface on an object; usually in the lathe.

Mat'tock. An implement with an iron head, having blades at each end presented in different planes, and an eye in the middle into which the handle is inserted perpendicularly to the head. The cutting edges are presented like those of an axe and an adze respectively.

The mattock, pick, grubbing-hoe, or a tool substantially similar and used for digging and grubbing, has been in use in Egypt and Palestine for nearly 4,000 years, as we know, and probably much longer.

The Egyptian hoe of the time of the Pharaohs was a large wooden implement, and answered for mattock, spade, and hoe. It had a single head, like the *surculus simplex* of Palladius, in contradistinction to the *bicornis,* or two-bladed tool, which resembled our pick. See HOE.

"They had a file for the mattocks." — 1 Samuel, xiii. 21 (1093 B. C.). By reference to Isaiah vii. 25, it appears that the mattock was relied upon for grubbing out briers and thorns as at present, and the pronged hoes of the Greeks had a similar duty in addition to their ordinary use in preparing the ground for seed.

Mat'tress. A padded bed, or one stuffed and quilted or tied, so as to keep the stuffing to a general thickness. The filling is hair, moss, sponge, cotton, husk, straw, *excelsior* (shredded wood), etc.

An elastic bed-bottom of coiled or woven wire.

Maul. A large wooden hammer, adapted for driving wedges, and sometimes called a *beetle.* (See MALLET.) A knot-maul (*x,* Fig. 3032) is made of a tough piece of timber, generally a knot chopped out of the side of a log. It is usually the frustum of a cone, the handle being inserted into an auger-hole bored through the axis and fastened by a wedge at the end.

The ring-maul (*y,* Fig. 3032) is a piece of a tough stick, gum, dogwood, hickory, or oak, with a hole passing transversely through it for the handle, and rings upon the ends to prevent splitting.

The iron-maul (*z,* Fig. 3032) has recessed faces to receive disks of wood, which are the working faces of the maul, as it is not fit that the iron should touch the object to be driven. A good maul is a valuable tool; and this iron-head, if carefully used,

will last a long time, the wooden faces being burned out when worn, and then renewed.

The light *maul* of the United States artillery service has a head of elm or hickory, 6 inches in diameter and 8 inches long; handle of ash, 1½ inches diameter, 24 inches long; an iron hoop on each end of the head 1 inch wide, ¼ inch thick. It is used for driving pickets. Weight, 10 pounds.

Maul-stick. (*Painting.*) A wooden rod on which an artist rests the right hand to steady it.

Maun'dril. (*Mining.*) A prying pick with two prongs.

Max'i-mum Ba-rom'e-ter. A barometer having an indicator so arranged as to follow the movement of the mercury up to the highest point which it may reach, and there remain stationary when the mercury recedes, thus showing the maximum hight of the column and consequent maximum of pressure during storms, etc.

Negretti and Zambras's contrivance for this purpose consists in jointing to the longer leg of a siphon barometer, at 8 inches from its top, a bent glass tube, which is carried up for 6 inches parallel to the main tube, joining it again at 2 inches from the top. The mercury flows freely in and out of this tube, maintaining the same level as that in the larger tube. It contains a small piece of steel, maintained in position by fine glass springs; as the mercury rises, the steel is pushed up, but remains stationary when the mercury descends. A similar contrivance in the shorter leg shows the minimum reading of the barometer.

Max'i-mum Ther-mom'e-ter. A thermometer arranged to register the highest point reached between observations, as Rutherford's. See THERMOMETER.

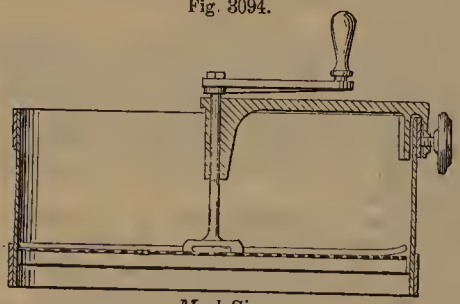
Meak. A hook with a long handle.

Mealed Pow'der. Gunpowder pulverized by treating with alcohol.

Meal'er. A wooden rubber for mealing powder.

Meal-sieve. (*Domestic.*) One for sifting cornmeal and flour, to remove portions of hulls from the former, lumps and weavil from the latter. The frame

Fig. 3094.



Meal-Sieve.

which rotates above the foraminous surface of the sieve is journaled in a frame attached by a clamp and set screw to the edge of the sieve.

Meas'ure. 1. A quantity assumed as a unit. See UNIT.

The measures of antiquity — and the modern have much the same origin — are derived from the parts of the human body.

The *finger-breadth* (*digitus*).

The *thumb-breadth* (*pollex*).

The *palm*, or hand-breadth (*palmus*).

The *span*, or distance comprised between the tips of the thumb and little finger when extended.

The length of the *foot* (*pes*).

The distance from the elbow to the tip of the middle finger (*cubit*).

A *step* = 30 inches (*gradus*).

A double-step or *pace* = 5 feet (*passus*).

The reach of the extended arms = 6 feet (*orgyia*).

The inch was not a unit of measure, but is the twelfth of a foot. The Greek measures were decimal, the Roman duodecimal.

The intinerary measure of distance was the *stadium*, the length of the foot-race course. The Olympic stadium was 600 feet.

The Roman measure of area was the *jugerum* = ⅘ of an acre English. Its name and quantity signify that it was a day's work for a *yoke* of oxen in plowing.

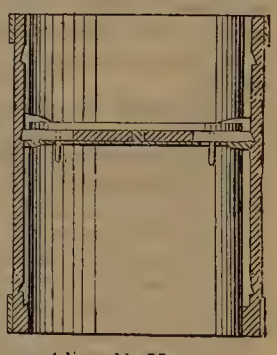
The *mille passuum*, or 1,000 paces, was the common name of the Roman mile.

A common Roman measure for land was the 10-foot pole, *pertica* or *decempeda*.

The unit of measure differs among different nations. See UNIT; METRIC SYSTEM.

Measures of merchandise and artificers' work are according to custom and trade: the yard and its fractions for woven goods; the fathom for rope; the bushel, peck, and gallon for grain and roots; the gallon and its subdivisions for liquids.

Fig. 3095.

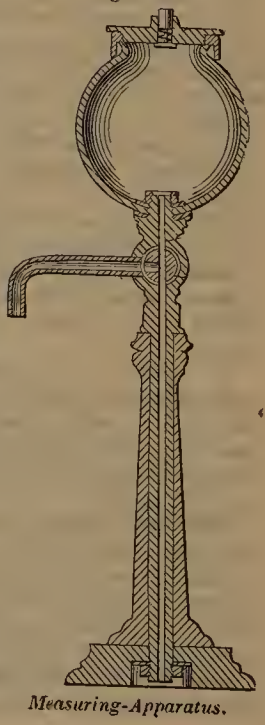


Adjustable Measure.

Fig. 3095 is a measure with a bottom adjustable for different quantities. Spring catches on the bottom are operated by projections beneath, and enter notches in the sides of the cylinder at the proper points.

The gallon, quart, and pint are used for small measures of capacity. For weight we have, foolishly enough, several kinds of pounds of varying weight, the avoirdupois weighing 7,000 grains and divided into 16 ounces, and the ounce into 16 drams; the Troy pound of 5,760 grains divided into 12 ounces, the ounce into 20 pennyweights, and the pennyweight into 24 grains; the apothecaries' weight of 5,760 grains, divided into 12 ounces, the ounce into 8 drams, the dram into 3 scruples, and the scruple into 20 grains. The grain is the constant. See books on weights and measures, Haswell's "Handbook," and the specific index under METERS.

Fig 3096.



Measuring-Apparatus.

Among measuring devices are those known as *rules*, *sticks*, *tapes*, *lines*, etc. See also lists under GAGES, CALCULATING AND MEASURING INSTRUMENTS, DRAFTING AND MATHEMATICAL INSTRUMENTS.

Besides these may be simply mentioned *measuring faucets*, *funnels*, *pumps*, *board*, *cloth*, *lumber*, *surveyor's*, *tailor's*, *tire measures*, etc. See also succeeding articles, which describe measuring attachments for tanks, stills, casks, faucets, funnels, tires, etc.

2. (*Joinery.*) *Single measure* is square on both sides; *double measure* molded on

both sides; *measure and a half*, molded on one side, square on the other.

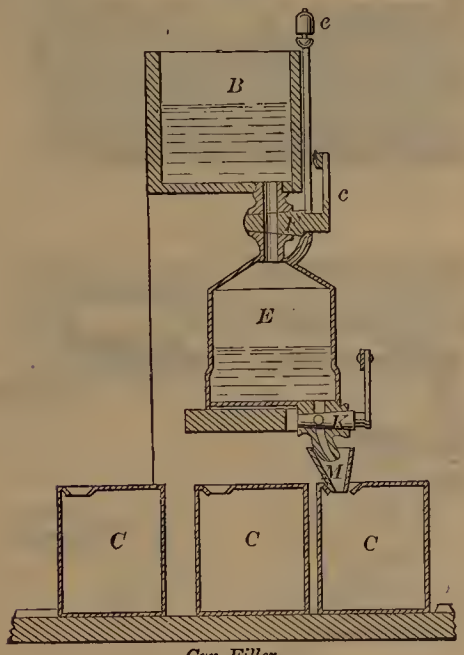
3. (*Mining.*) A stratum or bed of coal.

4. (*Printing.*) *a.* The space in a composing-stick between the end and the slide. The length of a line.

b. The width of a column or of a page of type.

Meas'ur-ing-ap'pa-ra'tus. A device for measuring liquid in transitu. In Fig. 3096 the liquid flows into the measuring-globe, and by the rotation of the faucet is shut off from the induction-pipe and drawn off by the eduction-faucet. The globe is of known capacity, and the successive fillings and emptyings are counted.

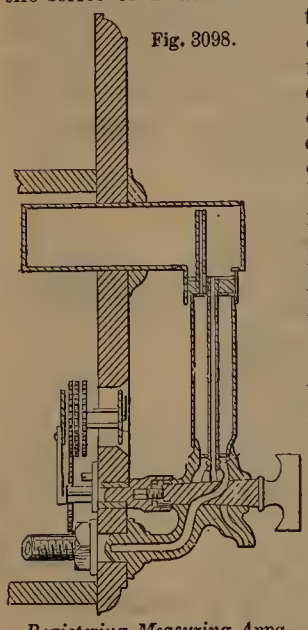
Fig. 3097.



Can-Filler.

Fig. 3097 is a device for filling cans of given capacity. A number of cans, *C C C*, stand in a row, and over each is a chamber *E* which has a measured capacity. The plug-levers *c* of the fill-cocks of the series of measures *E* are connected together so that one movement opens or closes them simultaneously. The discharge-cocks *K* are similarly connected. Whistles connected with the tops of the measures indicate by the passage of air the flow of liquid into the measures. Pivoted funnels *M* gravitate to the mouths of the cans on their presentation.

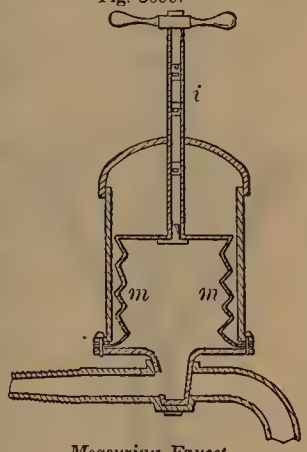
Fig. 3098.



Registering Measuring-Apparatus.

In Fig. 3098 the two-way cock allows the liquor to flow alternately into and from the receiver and connects with a register. The receiver communicates with an air-chamber above it, the compression of the air balancing the weight of liquor and assisting to empty the receiver. A pipe communicates from the air-chamber to the supply-pipe to keep up the equilibrium by discharging any liquor which had entered the air-chamber when the pressure of liquor was at its maximum.

Fig. 3099.



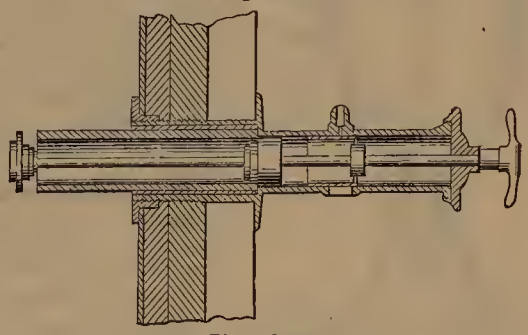
Measuring-Faucet.

Meas'ur-ing-chain. The SURVEYOR'S-CHAIN (which see).

Meas'ur-ing-fau'cet. A faucet which measures the amount of passing liquid. There are several types. In Fig. 3099, the chamber being in a position to form communication between the vessel to be drawn from and the interior of the flexible tube, the disk is raised so as to draw liquid into said tube, — the discharge end of the faucet being, in the mean time, closed. The chamber is then turned so as to reverse the direction of the tube's communication with the faucet, and, the disk being then depressed, the measured liquid is ejected from the tube through the outer end of the faucet. For drawing off a less quantity than the capacity of the flexible chamber *m m*, the stem *i* is graduated.

Another variety has a piston working in a glass

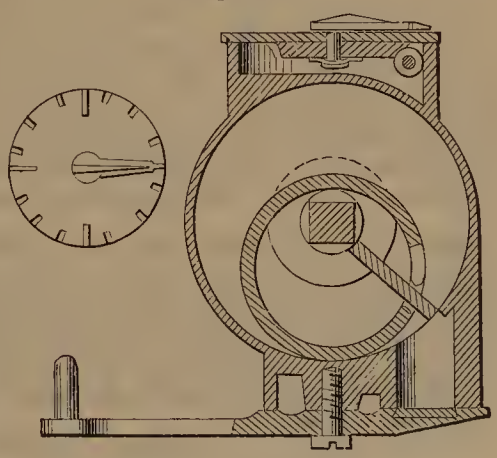
Fig. 3100.



Piston-Faucet.

cylinder of known capacity. The liquid included between the valve and piston is drawn forward to the discharge opening, which is unstopped by the motion of the inner sleeve.

Fig. 3101.

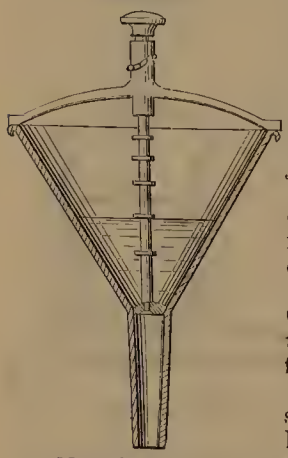


Baker's Measuring-Faucet.

Baker's measuring faucet is on the principle of the rotary pump. An eccentric in the chamber is revolved by a crank, and the sliding piston ejects at each revolution the known contents of the cylinder. A register on top keeps tally of the revolutions.

In another variety of this type, two cylinders work together, in the manner of Root's blower, projections on one entering cavities in the other, and each being packed against its own portion of the twin cylinder inclosing the two.

Fig. 3102.

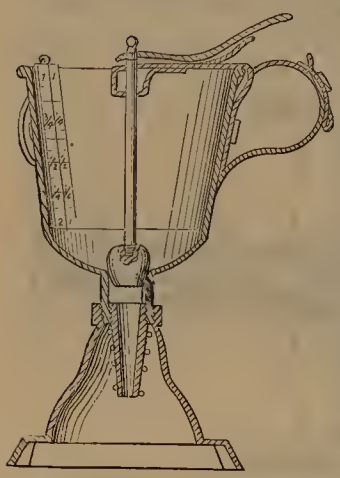


Measuring-Funnel.

Meas'ur-ing-fun'nel. One having graduations to indicate quantity at different degrees of fullness.

Fig. 3102 has a valve-stem, on which, at calculated distances, are small disks indicating the quantity of liquid in the funnel at different levels. To lift or close the valve, the stem is turned by its handle, when a projection from it ascends or descends an inclined slot in the collar ascending from the bar.

Fig. 3103.



Measuring-Funnel.

In Fig. 3103, the scale is marked on a bent strip which clips the side of the vessel. The stem of the valve is guided in a projecting bridge-piece, and the measure stands upon a detachable base.

Meas'ur-ing-ma-chine'. An instrument for ascertaining length, or "end measurement," with great exactness.

Whitworth's measuring-machine, which can be graduated to the one-millionth part of an inch, is shown in Fig. 3104, at *A B C*.

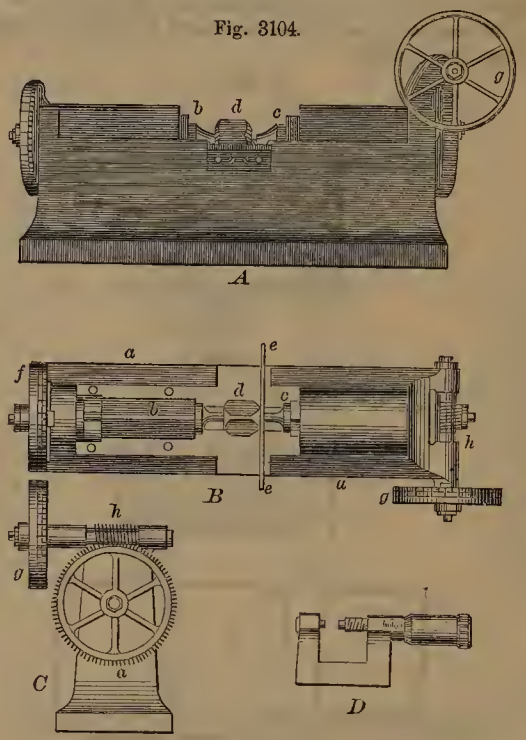
The solid bed of the machine *a* is carried up at the ends so as to form two head-stocks. A V-shaped groove runs from one of the head-stocks to the other, and in this groove the square bars *b* and *c* are laid, as is also the standard of the bar *d*, of which the length is to be tested. The sides of the groove and of the bars are worked up to as true a plane as possible, and are kept at right angles to each other. The ends of the bars are also made square with their sides and brought to true planes, the ends being turned down to present circular instead of square faces.

Through each head-stock runs an accurately pitched micrometer-screw, by which *b* and *c* are driven along the groove. The screw on the side of *b* has exactly 20 threads to the inch, and is turned by the wheel *f*, the circumference of which is divided into 250 parts. Consequently, by turning the wheel forward one division, the bar is moved one five-thousandth of an inch.

The other screw has a similar thread, is driven by a worm-wheel of 200 teeth, into which gears a tangent screw *h*, having fixed upon its stem the graduated wheel *g*. The circumference of this wheel being also divided into 250 parts, a movement of one division corresponds to a traverse of $\frac{1}{20} \times \frac{1}{200} \times \frac{1}{250}$ = one millionth of an inch on the part of the bar *c*. Fixed pointers enable the exact movement of wheels *f* or *g* to be read off, so that this extremely minute difference in the length of any bars may be detected, provided the micrometer screws exert an equal pressure in every case.

This equality of pressure is secured by a very sim-

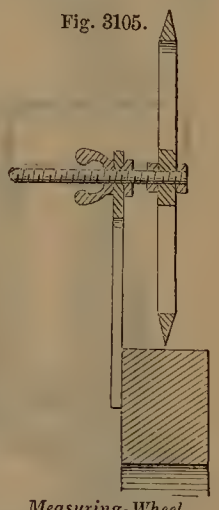
Fig. 3104.



Measuring-Machine.

ple and beautiful arrangement. Between one extremity of the bar under comparison and the sliding-bar a small steel piece, with true parallel sides, is introduced. This piece is called the *feeler*, and its ends *c c* rest upon two supports on the sides of the bed. When little or no pressure is exerted on the bar *d*, the feeler falls back of its own weight if one of its ends be raised. A very slight pressure prevents this falling back, and the friction between this piece and the ends of the bars becomes a very delicate measure of the pressure to which it is subjected.

Fig. 3105.



Measuring-Wheel.

D, Fig. 3104, is a pocket-instrument, made to measure to one thousandth of an inch. The screw has 50 threads to an inch, the head having 20 divisions on the circumference. Consequently, a turn of the head through one division advances the screw $\frac{1}{50} \times \frac{1}{20} = \frac{1}{1000}$ of an inch.

Meas'ur-ing-pump. One in which the piston operates in a chamber of known capacity, a train of wheels and dial registering the pulsations of the piston.

Meas'ur-ing-tape. A tape divided into inches and fractions, and coiled around an axis in a box; retracted by a spring or winding handle.

Paine's American steel-tape measure is made of a steel ribbon, divided into yards, feet, links, or some other unit of measurement. The metallic ribbon has many advantages over that made of linen, in respect of its not being affected by moisture, or liable to extension of length by tension. Measuring-tapes are frequently accompanied by registering devices, the axis of the tape being connected to a set of gearing and pointers in the manner described under ARITHMOMETER (which see). See Paine's patents of 1860.

Tape-measures are specifically made for surveying, lumber measuring, cloth measuring, etc.

Meas'ur-ing-wheel. 1. One for measuring the circumference of a carriage-wheel, in order to find the length of tire required. A *circumferentor*. The small wheel has a known circumferential measurement, and is divided into inches and fractions. The result is told in numbers of revolutions and fraction of a revolution expressed in inches. In the illustration the wheel has a guide which traverses against the side of the rim and assists in maintaining the measuring-wheel in place. A *circumferentor*; a *tire-measurer*.

2. An ODOMETER (which see).

Meat-bis'cuit. A portable, concentrated preparation of meat, pounded, dried, mixed with meal, and baked. It was originally introduced by Mr. Gail Borden.

For making meat-biscuits, good beef is selected and boiled by steam until all the nutritive qualities are extracted. The liquor is strained, allowed to settle, and then evaporated by heat to the consistence of thick treacle; the fat is skimmed off as it rises. While the liquor is yet hot, flour is added to it, and both are kneaded up into a stiff dough, which may then be rolled, pressed, made into biscuits, and baked. The biscuits are either kept whole or are ground to powder, and are preserved in air-tight cases. For making into soup, the powdered biscuit is mixed with hot water and boiled, with the addition of salt and other condiments.

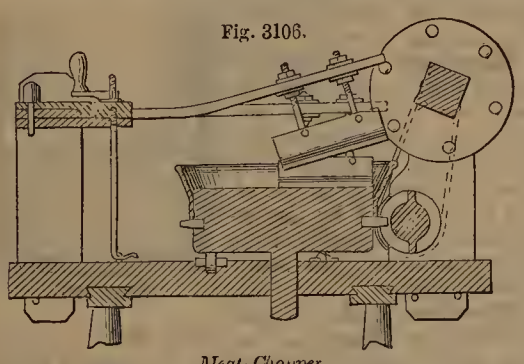
The process of Carr and Lucop consists in pulverizing plain biscuit, mixing this powder with the extract of meat, and subjecting the compound to a heavy pressure or stamping it in molds.

The same method is employed in making biscuit with preserved fruits or any material liable to be injured by the heat of the oven.

Cheese-biscuit are made by inclosing the powdered cheese between two layers of powdered biscuit, and pressing the whole in a mold.

Meat-chop'per. A machine for mincing meat for sausage or for stewing. Among the many varieties may be cited the kind having vertical knives

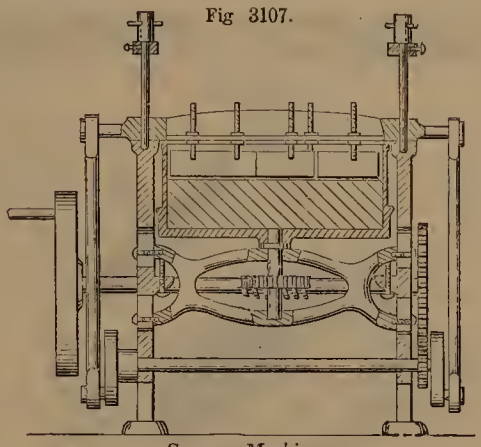
Fig. 3106.



Meat-Chopper.

on flexible or weighted stocks. In Fig. 3106, the block rotates by the engagement of its sprockets with the worm on the shaft. The cleavers are attached

Fig. 3107.

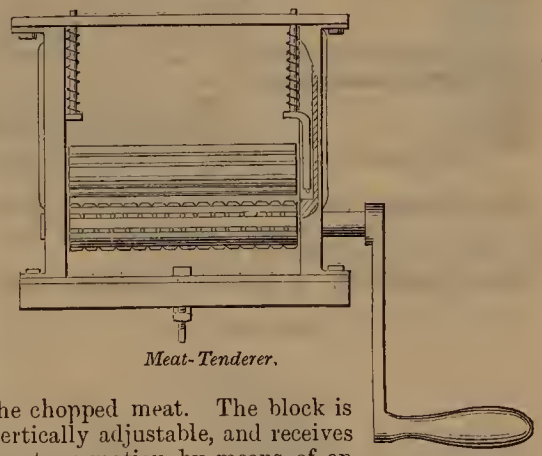


Sausage-Machine.

to spring arms, and the force of the blow is regulated by a nut on the pivoted block, in which their shanks are clamped.

Fig. 3107 has a revolving block, but the knives, instead of snapping, are simply reciprocated in guides by means of pitmans and gearing. The guides are removable to allow the cutter-heads to be inverted, to clean or sharpen the knives, and to remove

Fig. 3108.



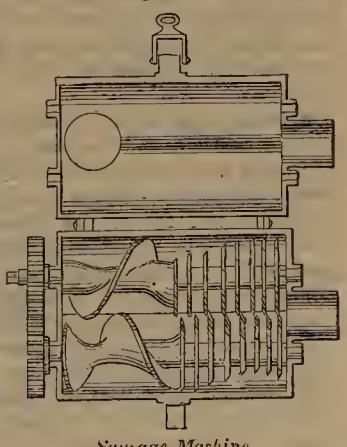
Meat-Tenderer.

the chopped meat. The block is vertically adjustable, and receives a rotary motion by means of an endless screw and worm-wheel. See also MEAT-CUTTER; SAUSAGE-MACHINE.

Meat-crush'er. A pair of rollers for tendering steak. In the example, one roller has circumferential and the other longitudinal corrugations.

Meat-cut'ter. A machine for mincing flesh. A *sausage-machine*. In Fig. 3109, the two sections of the shell have smooth surfaces and are hinged together. The cutters are interchangeable, and are placed in spiral relation upon the shaft, and with intervening washers, which regulate their distance apart. The worm on the shaft forces the meat between the knives, which make a shear-cut against each other, and so to the exit.

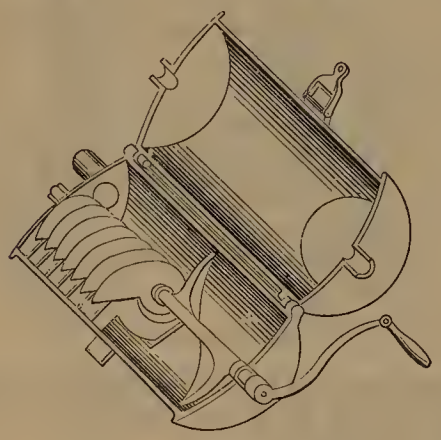
Fig. 3109.



Sausage-Machine.

In Fig. 3110 there is but a single system of moving cutters, which pass between knives attached to

Fig. 3110.

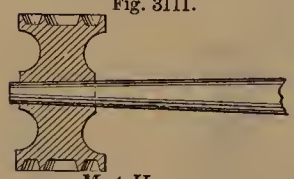


Meat-Cutter.

the shell, while the meat is forced forward by the screw, as in the former case.

Meat-ham'mer. A maul with a notched or ridged face, to pound meat and render it more tender, as in the example, where the hammer-face has angular projections.

Fig. 3111.



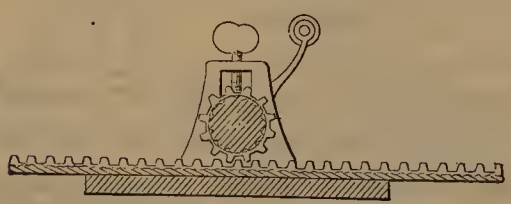
Meat-Hammer.

Meat-hook. One in a larder or on a butcher's stall, to hang joints of meat.

Meat-knife. One the haft of whose blade passes through the handle, which consists of two pieces known as *scales* and secured by rivets.

Meat-man'gler. A device for tendering steak.

Fig. 3112.



Meat-Mangler.

The roller has a roughened surface counterpart to that of the bed to which it communicates motion.

Meat, Pres'er-va'tion of. Mechanical or chemical appliances to prevent decay of animal food have been in use from the earliest ages. Freezing, salting, and drying meat for future use are older than history.

Freezing is perhaps the simplest and quickest mode of preservation, and answers well in cold climates. Attempts have been made to freeze meat by artificial means in countries where live stock is plenty, as in Australia and Texas, and transport it in a frozen state to market. Several hundred tons of beef were packed in a refrigerating ship in Australia, but the attempt to transport it to England failed because of the exhaustion of the supply of ice.

Dried meat is usually prepared by cutting in thin strips and hanging in the sun. The American Indians pound their meat in wooden mortars until it forms a paste, which is mixed with fat and dried in blocks. It is then called *pemmican*, is quite nutritious, and is used in large quantities by Arctic voyagers.

Artificially dried meat is usually more or less smoked in preservation. The pyroligneous acid and creosote contained in peat or wood smoke coagulates albumen, with which it comes in contact. So-called *smoked-meat* generally owes its preservation to the salt with which it is saturated, the creosote only penetrating a short distance.

Meat is salted either in a pickle or brine, or dry-salted, which latter way is more expensive, but retains more of the nutritive qualities of the meat.

A mode of salting by wholesale is by an injection of brine and saltpeter into the heart of the animal immediately after it is killed. The brine penetrates the whole vascular system, expelling the blood, and flows from the right ventricle in a clear stream.

The first attempt to preserve meat by canning in air-tight vessels was made by M. Appert, at Paris, 1810. His process consisted in partly cooking the meat, placing it in a glass vessel in a bath of chloride of calcium, and then hermetically sealing it.

The modern process of putting up "preserved meats" is substantially as follows: —

The meat is placed in the can, which is then filled up with soup. A cover pierced with a small hole is then soldered on. The can is placed in a bath of a solution of chloride of calcium, which boils at about 320° Fah. When the generated steam has expelled the air, a drop of solder closes the hole. When the can cools, the pressure of the air resulting from the condensation of steam bends in the heads, which become concave. The cans are then placed in a proof-chamber, and exposed to a tropical heat of say 120° Fah., as high as they will be apt to encounter. Taint in the meat, or imperfect closure, manifests itself by the bulging out of the heads.

Meat-saw. A saw with a thin blade strained in an iron frame and used by butchers.

Meat-screen. A metallic screen placed behind roasting meat to reflect back the heat of the fire.

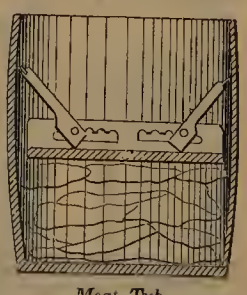
Meat-spit. One for holding a roasting joint

Fig. 3113.

Spit.

while turning in front of the fire. In the example, the spit has sliding skewer plates which have fixed and removable skewers. The spit is oblong in section, to prevent the skewer plates from turning thereon.

Fig. 3114.



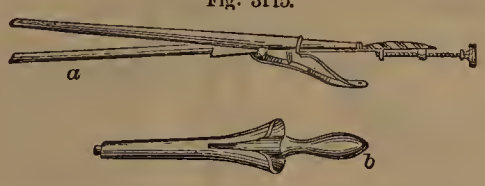
Meat-Tub.

Meat-tub. One for holding pickled meat. The example has a follower to keep the pieces below the surface of the brine. The cover lies upon the meat in the barrel, and is kept down by the engagement of the points of the pivoted arms with the inside of the barrel.

Me-a'tus-knife. A small knife with a triangular concealed blade in a long thin shaft; used in operations in the meatus auditorius, such as obliterating strictures, opening pustules, scarifying, removing polypi, etc.

a, meatus-knife. *b*, meatus-cope.

Fig. 3115.



Meatus-Knife and Meatuscope.

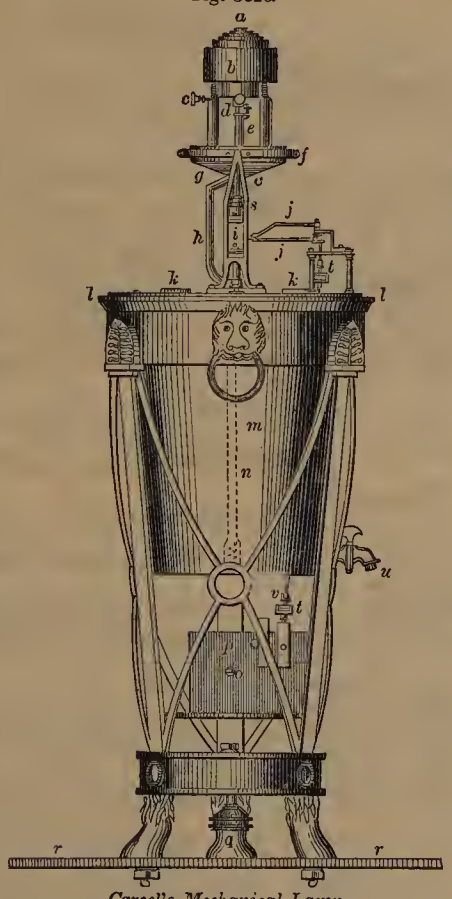
Me-a'tus-cope. A urethra speculum.

Me-chan'i-cal Broom. A sweeping-machine, usually propelled by horses, and having revolving brooms actuated by the supporting wheels, and delivering the dust and mud into the box of the wagon. See STREET-SWEEPING MACHINE.

Me-chan'i-cal Lamp. Another name for Carcel's clock-work lamp, in which the oil is pumped from a lower reservoir to the wick-tube by means of clock-work, so as to furnish a supply exceeding that consumed by the wick, the surplus flowing back outside of the burner. The object is to afford equal and ample supply of oil to the flame.

A spiral spring and piston in the reservoir have been used as a substitute for the clock-work pump, which is objectionable on account of its expensiveness for domestic uses, but is valuable in important situations, such as lighthouses.

Fig. 3116.



Carcel's Mechanical Lamp.

James Watt, in a letter to Argand, August 8, 1787, gave sketches of proposed lamps with oil-pumps worked by clock-work. See "Engineer," Vol. I. p. 37.

Fig. 3116 represents a mechanical lamp adapted for dioptric lights of the first order.

a, wick-holder.
b, glass-holder.
c, screw to rack for raising wick.
d, rack for raising wick.
e, pipe supplying oil to wick.
f, collar supporting burners.
g, drip-cup.
h, return-pipe for overflowing oil.
i, valve-box.
j, crank-rods for working leathern valves.
k, hinge of lid.
l, lid of cistern.
m, oil-cistern.
n, suction-pipe.
o, winding-arbor for clock-work.
p, box for clock-work.
q, screw for adjusting level of burner
r, service-table.
s, coupling-screw for oil-tube.
t, uuiversal joints for connecting-rod.
u, cock for emptying cistern.
v, connecting-rod for cranks.

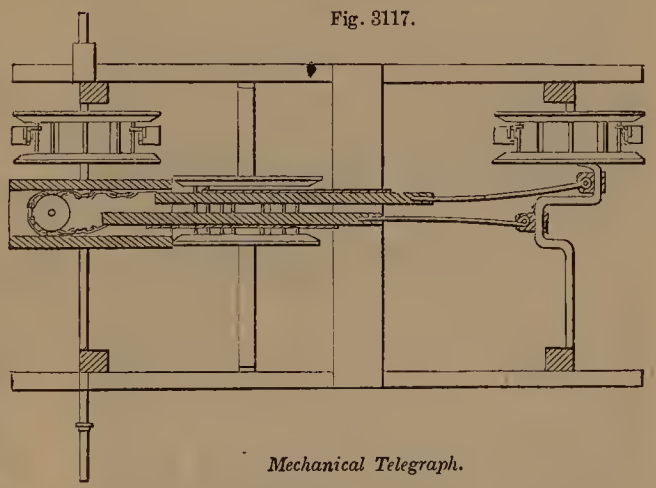
Me-chan'i-cal Leech. See LEECH, ARTIFICIAL.

Me-chan'i-cal Pi'geon. A flying object forming a substitute for a pigeon in shooting-matches. See PIGEON.

Me-chan'i-cal Tel'e-graph. Another name for the automatic telegraph, in which a message represented by a series or succession of dots is passed beneath a key or stylus, so as to make and break the circuit by simply mechanically passing through.

In another apparatus of local use perhaps, but not susceptible of application to distant points, the apparatus has bell-cranks which stand at angles of 120° with each other; the crank of the shaft at one station is connected by rods with that of the other. Endless chains with lettered links pass around the wheels, correspondence being maintained between the two; one being actuated by an operator to bring given letters in series to a fixed point, the corresponding letters are brought by synchronous action to analogous position on the other to be viewed by the observer at that point.

Fig. 3117.



Mechanical Telegraph.

Me-chan'o-graph. One of a set of multiplied copies of an original, executed by means of a machine.

Mèche. (*Surgical.*) A bunch or pledget of charpie, cotton, or raw silk, for keeping open an ulcer or wound. Applied by an instrument known as a *porte-mèche.*

Mech'lin-lace. (*Fabric.*) A light Belgian lace with an hexagonal mesh; made of three flax threads, twisted and plaited to a perpendicular line, the pattern being worked in the net, and the plait-thread surrounding the flowers.

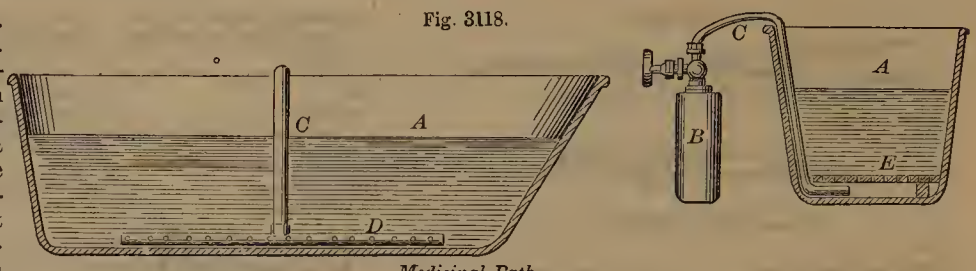
Me-com'e-ter. (*Surgical.*) A graduated instrument used at the Hospice de Maternité in Paris, to measure new-born infants.

Med'al. An ancient or a memorial coin.

Me-dal'lic En-grav'ing. In this beautiful art the direction and distance of the lines are so modified as to give the appearance of a figure or object in relief. It is executed by machinery. The machines of M. Collas and Mr. Bate, as well as those of Asa

Spencer, Mr. Froude, and Mr. Saxon, are all improvements upon an apparatus described in a French work, the "Manuel de Tourneur," about 1814. This machine will give a good general idea of the construction of these machines, and its operation is as follows: —

Fig. 3118.



Medicinal Bath.

The medal and the copper on which the medal is to be engraved are fixed on two sliding plates at right angles to each other, and so connected that when the plate on which the metal is fixed is raised vertically by a screw, the side holding the copper plate is advanced by an equal quantity in the horizontal direction. The medal is fixed on the vertical slide, with its face toward the copper plate and a little above it. A bar, terminating at one end in a tracing-point and at the other in a short arm at right angles with the bar, and holding a diamond-point, is placed horizontally above the copper, so that the tracing-point shall touch the medal to which the bar is perpendicular, and the diamond-point shall touch the copper plate to which the arm is perpendicular. Under this arrangement, the bar being supposed to move parallel to itself, and consequently to the copper, if the tracing-point pass over a flat part of the medal, the diamond-point will draw a straight line of equal length upon the copper; but if the tracing-point pass over any projecting part of the medal, the deviation from the straight line by the diamond-point will be exactly equal to the elevation of the corresponding point of the medal above the rest of the surface. Thus, by the transit of this tracing-point over any line upon the medal, the diamond will draw upon the copper a section of the medal through the line. A screw is attached to the apparatus, so that if the medal be raised a very small quantity by the screw, the copper plate will be advanced by the same quantity, and thus a new line of section may be drawn. By continuing this process, the series of sectional lines upon the copper produces the representation of the medal on a plane, the outline and the form of the figure arising from the sinuosities of the lines and from their greater or less proximity.

Me-dal'lion. 1. A large medal.

2. A carved, molded, cast, or stamped circular ornamental work.

Med'al-ma-chine'. A machine for making copies of medals and raised or sunk works on a scale larger or smaller than the original. It comprises adjustable frames on the pantograph principle for carrying tracers which pass over the face of the original, and mandrels in which the various cutters for producing the copy are inserted. It operates upon the CARVING-MACHINE (which see).

Med'i-cat-or. (*Surgical.*) A spoon, syringe, or insufflator, for directing a medicament into or upon a deeply seated part.

Me-dic'i-nal Cup. One for the administration of medicine to persons prostrated by sickness or injury. Some such cups have graduations to indicate quantity; or a tubular handle through which the liquid may be conducted to the mouth without spilling; or the lip of the cup has a little hood which constitutes an aperture through which the liquid is poured. Another cup resembles a pipette, discharging at the lower opening when the finger is temporarily withdrawn from the orifice in the upper end.

A medicinal cup of a former age was of antimony, rendering emetic a dose of wine allowed to stand therein.

Me-dic'i-nal Bath. In the apparatus, Fig. 3118, the medicinal vapors are forced, by their own pressure or otherwise, from the reservoir *B* through the pipe *C*, and, entering the bath-tub *A* beneath the perforated false bottom *E*, through the longitudinal perforated pipe *D*, pass upward in bubbles.

Med'i-cine-spoon. A spoon for the administration of medicines. As in the example, it may

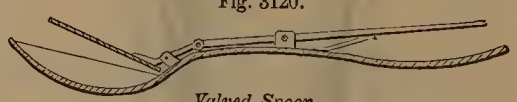
Fig. 3119.

Medicinal Spoon.

consist of a common teaspoon, provided with an adjustable lid which covers the bowl, leaving a small aperture at the tip, whereby the contents escape when the spoon is introduced into the mouth. The spoon is filled at the aperture near the handle.

In another form the cover is connected to a compound lever, which is influenced by a spring to close it. The cover is depressed by the lever. A portion

Fig. 3120.



Valved Spoon.

at the point of the spoon is left uncovered to allow the exit of the medicine.

Me'di-um. A size of drawing and writing paper between demy and royal, measuring $22\frac{1}{4} \times 17\frac{1}{4}$ inches, and weighing 20 to 34 pounds to the ream.

Of printing-paper, 19×24 inches.

Med'ley. (*Fabric.*) Cloth woven from wool dyed of various colors and spun. Technically, blue and black are excluded. First made in 1614.

Meer'schaum. Meerschaum (foam of the sea), a superior species of white clay, chiefly consisting of silicate of magnesia, and dug mostly in the peninsula of Natoli, Asia Minor. It is sent to market in irregular blocks of different sizes, the latter fixing the price, which is much higher in proportion for large lumps than for small ones. The Turkish government owns the mine and stipulates the quotations according to the demand, which generally exceeds the supply.

In manufacturing pipes, the lumps are cut into shape with a knife, after having been lightly wetted; the bowls are then carefully rubbed to obtain a clear, smooth surface, and afterward boiled either in pure wax, or wax, oil, and fats, the latter effecting a yellow hue, and facilitating the coloring.

Meet'ing-post. (*Hydraulic Engineering.*) That stile of a canal-lock gate which meets the corresponding stile of the other gate at the midwidth of the bay. See LOCK-GATE.

Me-gal-eth'o-scope. An improved form of stereoscope invented by Ponti, in which the photograph is considerably magnified and an increased appearance of sphericity obtained.

It is so arranged that the object may be viewed by direct or reflected sunlight, or by artificial light. — Prac. Mech. Jour., 3d series, Vol. III. p. 111.

Me-gam'e-ter. 1. An instrument for determining the longitude by observation of the stars.

2. A micrometer.

Meg'a-scope. (*Optics.*) 1. A solar microscope in which the objects are opaque and illuminated in front by reflecting mirrors.

2. An optical instrument for exhibiting an object on a large scale.

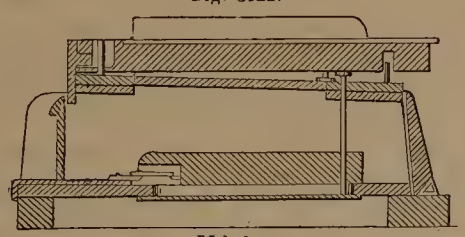
Me-gass'. Refuse sugar-cane from which the juice has been expressed. See BAGASSE.

Meir. (Eng. *local.*) Thirty-two yards of ground in a vein of ore.

Me-lan'o-type. (*Photography.*) Sometimes written *melainotype*. A process which takes its name from the *black* ground of varnished sheet-iron supporting the collodion which receives the picture. Also called FERROTYPE (which see).

Me-lo'de-on. (*Music.*) A wind-instrument with a row of reeds and operated by keys. The instrument has a bellows which formerly blew air through the reeds; but Carhart in 1846 patented the feature of drawing air through the reeds by suction bellows: he also invented machines to make, rivet, and plane the reeds; also the *tube board* to hold

Fig. 3121.



Melodeon.

the reeds, a machine to rivet the reeds to the blocks, and one for cutting the cells in the reed-board. Pressure on the key drives down the pin and the valve, allowing passage to the air. The principle is the same as the accordeon. *Flutina*, *parlor-organ*, *harmonium*, *seraphine*, are all names of instruments of this kind.

Mel'o-type. (*Photography.*) A process in photography in which a dark chamber is not used, and the pictures are developed at a subsequent convenient time.

Melt'ing-fur'nace. A foundry cupola, or a glass-maker's furnace.

Melt'ing-point. That point of the thermometer at which a substance becomes fused. See FUSING-POINT; THERMOMETER. See also p. 1422.

Mel'ton. (*Fabric.*) A kind of broadcloth for coating.

Me-nis'cus. A lens convex on one side and concave on the other. See LENS.

The concave side has a curve of greater radius than the convex side, and the lens is thicker in the middle than elsewhere.

In this respect the meniscus differs from the *concavo-convex lens*, whose convex face has a curve of greater radius.

Men's Har'ness. An arrangement by which men are attached to a gun-carriage which is to be moved but a short distance or where animal power cannot be employed. It consists of a rope 18 feet long and 4 inches in circumference, having a thimble at one end and a thimble and hook at the other. Ten leather loops are fixed in pairs to the rope, 5 on each side. These are of sufficient size to allow a man to pass his body through them, the strain of the draft coming on his chest.

Men'stru-um. A solvent, such as water, alcohol, ether, acids, oils, etc.

Men'tal. A basket made water-tight, and having four ropes attached, by which two men dip water

Fig. 3122.

Mental.

from a stream or cistern and discharge it into a trench for irrigation.

Mer-ca'tor-chart. A mode of projection invented by Gerald Mercator, in which the meridians and parallels are straight and parallel lines. The meridians are equidistant, but the distance between the parallels increases from the equator towards either pole. See CHART; MAP.

Mer'chant-i'ron. Bar-iron.

Mer'chant-rolls. Finishing rolls of a rolling-mill.

Mer'chant-train. A train of rolls with grooves of varying sizes and shapes, which reduce the reheated *puddle-bars* to bar-iron of merchantable form.

Mer-cu'ri-al Bath. Used in the pneumatic trough in collecting such gases as are largely absorbed by water.

Mer-cu'ri-al Gage. The pressure-gage in which the steam acts upon a body of mercury and raises a column in a glass tube.

Mer-cu'ri-al Horn-ore. Horn quicksilver.

Mer-cu'ri-al Lev'el. A form of level in which mercury is used.

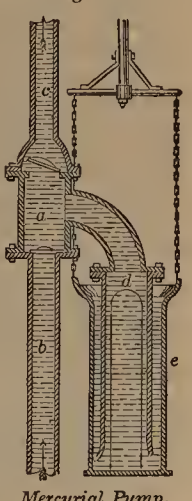
Mer-cu'ri-al Pen'du-lum. A compensation pendulum invented by Graham of London, 1700.

A jar of mercury is used for the *bob* or weight. As the pendulum expands the mercury rises, and by the rise of its center of gravity compensates for the other inequality. See PENDULUM.

Mer-cu'ri-al Pump. A pump invented by Haskins in 1720, in which a column of mercury acts as plunger and piston packing.

Fig. 3123 shows a pump of this form. *a* is the chamber of the pump, with a valve at each end opening upwardly. *b* is the suction-pipe, and *c* the outlet. A bent tube connects chamber *a* with cylinder *d*, open at bottom and surrounded by a large cylinder or cup

Fig. 3123.



Mercurial Pump.

e filled with mercury, or with a wooden core to save a portion of the mercury, as in the illustration.

If now the cup *e* be lowered, the tendency will be to produce a vacuum in chamber *a*, which will be immediately filled with water from the inlet pipe. By raising cup *e* the water will be expelled through *c*.

Mer-cu'ri-al Ther-mom'e-ter. A thermometer tube filled with mercury, in contradistinction to a spirit, air, or metallic thermometer.

Mer'cu-ry. Equivalent, 100; symbol, *Hg.*; specific gravity, 13.59; fusing-point, −39° Fah. Fluid at ordinary temperatures.

Occurs principally as a sulphide (*cinnabar*). It is a brilliant, silver-white, heavy metal. Distills at 662° Fah.

It is used in medicine associated with chalk (*blue pill*) and lard (*mercurial ointment*).

The chloride is corrosive sublimate, used in the Kyan wood-preserving process; and the sub-chloride is calomel.

The metal is used in philosophical instruments, — barometers, thermometers, etc.

An alloy of mercury with another metal is called an AMALGAM (which see).

Mercury is used to extract gold or silver from the earthy and baser metallic constituents of these ores; amalgamating with the gold and silver when brought into contact therewith. See AMALGAMATOR; SILVER-MILL, etc.

An amalgam of tin, 4, mercury, 1, is used to *silver* looking-glasses.

Many metals amalgamate with mercury, and others do not.

Added to certain fusible alloys it reduces their point of fusion below the heat of boiling water. See ALLOY, p. 62.

The ore of mercury — chiefly cinnabar, the sulphide of mercury — is broken, sifted, and crushed. It is then heated in a furnace with lime, iron, or some other agent which combines with the sulphur.

The mercury is vaporized, passes off, and is condensed into a metallic form. It is purified by filtration and stored in iron bottles.

Quicksilver has been mined from time immemorial in Spain at Almaden in the province of La Mancha. "Dioscorides separated mercury from cinnabar." (HUMBOLDT.) Pliny states that 700,000 pounds (of cinnabar?) were received yearly from that source, and that the Greeks received it from thence 800 years previously to the date at which he wrote (A. D. 70). (See AMALGAM.) It is now mined extensively at Idria, in the Schiefergebirge, and is found in Hungary, many parts of Germany, in China, Japan, Mexico, Honduras, Columbia, Peru, and California.

The modes of obtaining mercury by the decomposition and distillation of cinnabar have been very imperfect and wasteful; and even at this day, with all the advantages of skill and capital, the actual product is but a small proportion of the amount obtained by a careful analysis. It is understood that in Europe the ores are heated upon open arches and the vapors condensed within brick chambers.

For detailed description of the process and apparatus, we must refer the reader to Ure's Dictionary and chemical treatises, as the subject is not so clearly within the scope of this work that it can be treated at any length.

The extensive quicksilver mine of New Almaden is twelve miles from San José in California, and has had the benefit of energy, skill, and capital in its development. A good description of the place and the works was written in 1857, and given in Harper's "Magazine," June, 1863. Changes may have since taken place. The mode of mining and breaking into pieces suitable for the furnace has nothing peculiar to offer, but the condensing-furnaces are worthy of notice. They are sixteen in number, arranged side by side, and extend a distance of several hundred feet beneath a spacious roof. They stand 8 feet apart, are 40 feet in length, 10 in hight, and 8 in breadth. The ore is cleaned, broken, and dumped into the receiving-chamber, which is next to the furnace, and holds 7 tons of ore. The cover being luted on, the sublimated vapors pass by a circuitous route through 12 chambers successively, the connecting apertures being alternately at the tops and bottoms of the division walls. The mercury condensed in each chamber passes through small holes in the side to a covered trough on the outside, which conducts it to a reservoir, whence it is dipped into iron flasks which receive a charge of 75 pounds, and are then closed by a screw cap. While passing from the last of the twelve to the stack, the vapor is brought into contact with a pan of water, which still farther condenses escaping fumes.

Mer'cu-ry-fur'nace. A furnace in which cinnabar is treated for the production of mercury.

The localities yielding the sulphide of mercury are not numerous. The Almaden mines of Spain were known to the Greeks 700 B. C., and were celebrated in the time of Pliny. The mines of Idria, the Palatinate, and of New Almaden in California, are extensive and rich. The ore is also found in Peru, China, Hungary, Sweden, Japan, and Chili.

In the furnace the ore is subjected to distillation in retorts which lead to condensing-chambers, or the blocks of ore are roasted in a furnace, the whole volatile results of the furnace passing with the metalliferous fumes to a series of condensing-chambers. See CONDENSER. See previous article.

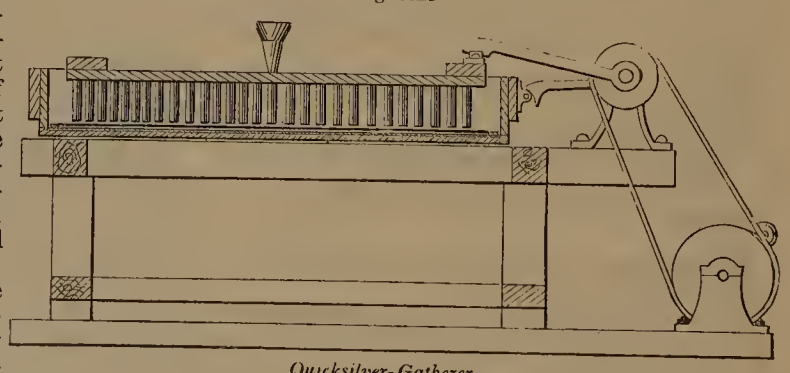
The latter is the plan adopted at Idria in Austria, the former in Bavaria and California. Dr. Ure's retort-furnace, erected at Landsberg in Bavaria, resembles the apparatus for the distillation of coal-gas.

In Spain, the old Buytrone or Aludel furnace is still adhered to. See ALUDEL.

Mer'cu-ry-gath'er-er. (*Metallurgy.*) A stirring apparatus in which *floured* quicksilver, which has been rendered what is technically known as *sick*, is gathered together. See AMALGAM.

Mercury which is *floured* is in a sort of powdery condition, the particles being coated with sulphur from the pyrites or from other cause; and the object

Fig. 3124.



Quicksilver-Gatherer.

of the mechanical agitation and rubbing, in the mercury-gatherer, is to cause the globules of mercury to coalesce and resume the fluid condition.

Me-rid'i-an. A great circle supposed to pass through both poles, and the zenith and nadir of a given place.

Me-rid'i-an-cir'cle. 1. A transit instrument with a graduated circle securely fastened at right angles to the horizontal axis and turning with it.

The meridian circle in the National Observatory of Washington was made by Ertel and Son, of Munich. Its object-glass has an aperture of 4½ inches, with a focal distance of 58 inches. This instrument is provided with a circle 30 inches in diameter, divided into arcs of 3′, and reads by four micrometers to single seconds.

2. The altitude circle of a globe.

Me-ri'no. (*Fabric.*) A fine, French, woolen goods, so named as being made of the wool of the merino sheep. It is a lady's dress goods, all wool, and twilled on both sides.

The Merino variety of sheep is a native of Spain, which country was celebrated for its wool in the time of Pliny.

The greater number of the sheep of Spain belong to the *mesta*, or merino corporation, which has about 5,000,000 sheep in flocks of 10,000 each. Each flock has an officer, 50 shepherds, and 50 dogs.

In summer, the sheep feed upon the elevated lands of Biscay, Navarre, and Arragon, and toward winter are driven southward to the fertile plains of New Castile, Andalusia, and Estramadura. The lambs come in January, and shearing commences the 1st of May, being carried on in houses where the flocks of sheep are folded on their northern march. 125 men shear 1,000 ewes per day, 50 weathers per man being considered a day's work. The ewes yield from 4 to 5 pounds of wool, the weathers from 7 to 8. The wool of each sheep is sorted into four varieties.

The carcass is but little esteemed.

The institution of the *mesta* dates from the time of the plague in 1350, when whole provinces were nearly depopulated and vast estates became ownerless. The proprietors of neighboring estates combined to throw the unoccupied tracts into a common pasture on which they herded sheep according to an agreed ratio.

Free passage is allowed to the flocks through the cultivated territories, and great hardship results. The power of this tyrannical corporation was somewhat reduced by the French, during their temporary occupancy of the country, 1808–12; a better legacy than any left by the succeeding English occupation, which was all in the interest of aristocracy and monopoly.

The merinos are now kept in immense numbers in Australia and Van Dieman's Land.

Turdetania, the country of the Guadalquiver, was famous for the quality of its wool in the time of Strabo, about the Christian era. A buck of fine quality was worth a talent (? Attic), equal to 1,180 dollars.

They were introduced into England in 1788.

Mer'kin. A mop for cleaning cannon.

Mer'lon. (*Fortification.*) The solid part of an embattled parapet, between two embrasures.

Mesh. 1. (*Gearing.*) Or *mash.* The engagement of the teeth of wheels with each other or with an adjacent object, as the rack, in a rack and pinion movement.

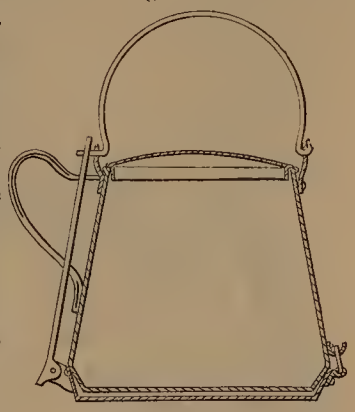
2. (*Netting.*) The loop made over a stick and engaging the loop in its vicinity.

Mesh-stick. (*Netting.*) A flat slat with rounded ends, used to form the mesh of nets, the loops being made over it and knotted on its edge.

Mes'sen-ger. (*Nautical.*) A rope passing from the capstan to the cable to which it is fastened by nippers. The winding of the messenger on the capstan hauls in the cable and the nippers are successively taken off that part of the cable that is approaching the capstan, and put upon that part which has just come inboard, through the *hawse*-hole.

Mess-kit. That portion of camp equipage consisting of cooking-utensils.

Fig. 3125.



Mess-Kit.

In the example, a frying-pan or griddle is conveniently attached to the bottom of the coffee-pot, by passing the handle of the pan up through a hole made in the handle of the coffee-pot, and then catching it by passing the end of the bail through a hole in its upper end, for convenience of transportation.

Met'a-car'pal Saw. (*Surgical Instruments.*) A narrow-bladed saw, about six inches long, used for dividing the bones of the fingers or middle hand or of the foot in amputation. In former times they were made with small bows: they are now straight, stiff-bladed, ground thinner on the back, to make them follow the cut easily; or thin-bladed with a stiffening *back*, which, after having cut to the depth of the blade, can be raised, when the blade will follow in the cut. See p. 92.

Met'al. 1. An elementary mineral substance possessing certain attributes, particularly the luster called metallic, by which it is distinguished from other inorganic productions. With few exceptions, metals possess considerable specific gravity, hardness, and cohesion, and require a high degree of heat to liquefy them. One, mercury, is liquid at ordinary temperatures, and a very few, as sodium and potassium, are lighter than water, which they decompose with such energy as to produce combustion.

The properties and qualities of metals by which distinctive descriptions are drawn are, —

Specific gravity, chemical equivalents, fusibility, hardness, brittleness, malleability, ductility, tenacity, elasticity, opacity of surface, sonorousness, color, lustrousness, odor, taste, dilatation by heat, specific heat, conductivity of heat, and also of electricity, magnetic or diamagnetic character.

The metals constitute about five sixths of the elementary bodies known to exist. They are distinguished by a peculiar luster, by their opacity, their power of conducting heat and electricity, and generally by a specific gravity considerably exceeding that of water.

Metals have been divided into five classes, principally depending upon their affinity for oxygen and the nature of the compounds formed by the union.

2. (*Civil Engineering.*) *a.* Broken stone for roads, according to the McAdam principle.

McAdam laid at most 10 inches of *metal* on a surface prepared by leveling and sloping.

Telford laid as a bottoming a compact layer 7 inches thick of pieces from 4 to 7 inches in dimension. Over this he spread the *metal*, which was made of a size to go through a ring 2½ inches in diameter.

METAL.	Symbol.	Equivalent (old system).	Atomic Weight (new system).	Specific Gravity.	Fusing-Point, — Degrees Fah.	Specific Heat.	Linear Expansion in being raised from 32° to 212° Fah.	Magnetic or Diamagnetic.	Order: Mag. or Diamag.	Order of Malleability.	Order of Ductility.	Tenacity, — Wire one tenth Inch Diameter sustains Pounds.	Conductivity,* Silver being 100. For Heat.	Conductivity,* Silver being 100. For Electricity.	Discoverer.	Date.	Derivation of Name.
Aluminium, cast...	Al.	13.7	27.49	2.56	1,562	.2143				7	10		66		Wöhler.....	1827	Lat., *Alumina* (alum).
Aluminium, rolled.				2.67													
Antimony.....	Sb.	122	122	6.71	797	.0508	$\frac{1}{923}$	Diamg.	2				21	5	Valentiue...	1450	Arabic, *Al-ithmidun.*
Arsenic.....	As.	75	75	5.8		.0814		Diamg.	12					5	Schroeder...		Gr. *Arsenikon* (potent).
Barium.....	Ba.	68.5	136.84		887										Davy.....	1808	Gr. *Baros* (heavy).
Bismuth.....	Bi.	212	210.34	9.823	500	.0308	$\frac{1}{719}$	Diamg.	1				6	1	Agricola	1529	Ger. *Wisemat.*
Cadmium.....	Cd.	56	112.12	8.655	617	.0567		Diamg.	5	11	7		58	24	Stromeyer ..	1818	Gr. *Cadmia* (calamine).
Calcium.....	Ca.	20	40.21	1.578											Davy.....	1808	Lat. *Calx* (lime).
Chromium.....	Cr.	26 7	52.5	6.81	3,992			Mag.	5						Vauquelin ..	1797	Gr. *Chroma* (color).
Cobalt.....	Co.	29.5	58.8	8.95	3,272	.1069		Mag.	3	13	8			17	Brandt	1733	Ger. *Kobold* (a goblin).
Copper.....	Cu.	31.7	63.49	8.95	1,742	.0950	$\frac{1}{582}$	Diamg.	10	3	5	600	84	99			Lat. *Cyprium* (Cyprus).
Gold.....	Au.	93	196.66	19.34	2,282	.0324	$\frac{1}{661}$	Diamg.	11	1	1	200	98	78			Hebrew.
Iridium.....	Ir.	99	197.1	21.15	3,992	.0326		Diamg.	15						Tennant.	1804	Lat. *Iris* (the rainbow).
Iron.....	Fe.	28	56.08	7.844	2,912	.1138	$\frac{1}{812}$	Mag.	1	6	4	570 - 720	44	17			
Lead.....	Pb.	103.5	206.91	11.36	617	.0314	$\frac{1}{351}$	Diamg.	8	10	13	18	29	8			
Lithium.....	Li.	6.9	7.02	0.593	374	.9408					16			19	Arfwedson...	1817	Gr. *Lithos* (a stone).
Magnesium.....	Mg.	12.2	24.6	1.743	1,382						15				Davy	1807	Magnesia in Asia Minor.
Manganese.....	Mn.	27.6	55.7	8.013	3,452	.01217		Mag.	4						Gahn.....	1740	Magnesia in Asia Minor.
Mercury.....	Hg.	100	200	13.596	—40	.0318		Diamg.	7					2			The deity and planet.
Molybdenum.....	Mo.	46	96	8.62	3,632	.0722									Hjelm	1782	Gr. *Molybdos* (lead).
Nickel.....	Ni.	29 6	58.8	8.82	2,912	.1086		Mag.	2	12	9			13	Cronstedt...	1751	Ger. *Kupfernickel.*
Osmium.....	Os.	99.6	198.8	21 4	3,992	.0306		Mag.	10						Tennant	1804	Gr. *Osme* (odor).
Palladium.....	Pd.	53.3	106.47	11.8	3,632	.0593	$\frac{1}{1000}$	Mag.	8	5	6	280		18	Wollaston ..	1803	The goddess and asteroid Pallas.
Platinum.....	Pt.	93.7	197.1	21.5	3,992	.0324	$\frac{1}{1131}$	Mag.	9	4	3	560	38	18			Sp. dim. of *Plata* (silver).
Potassium.....	K.	39.2	39.13	0.865	131	.1695									Davy	1807	Eng. *Potash.*
Rhodium.....	Ro.	52.2	104.3	12.1	4,352	.0580		Diamg.	14						Wollaston...	1804	Gr. *Rhodon* (a rose).
Silver.....	Ag.	108	107.93	10.53	1,832	.0570	$\frac{1}{524}$	Diamg.	9	2	2	400	100	100			
Sodium.....	Na.	23	23.04	0.972	194	.2934		Diamg.	6				36		Davy	1807	Lat. *Salsola* (soda).
Strontium.....	Sr.	44	87.25	2.54										7	Davy	1808	Strontian in Scotland.
Tellurium.....	Te.	64	128.3	6.25	752										Müller.....	1782	Gr. *Tellus* (the earth).
Tin.....	Sn.	59	118	7.294	428	.0562	$\frac{1}{516}$	Diamg	4	8	12	48	42	12			
Tungsten.....	W.	94	184	17.6	4,352	.0334		Diamg.	16						De Luyart...	1786	Sw. *Tungsten* (a heavy mineral).
Uranium.....	U.	60	120	18.4	3,632			Diamg.	13						Klaproth ...	1789	The deity and planet Uranus.
Zinc.....	Zn.	32.5	65.04	7.146	707	.0955	$\frac{1}{340}$	Diamg.	3	9	11	75	64	29	Paracelsus...	1541	

This list does not include a number of rare metals which are not known out of the laboratory, and have no importance as yet in the arts.
The data, with the exception of the equivalents (old system), fusing-points, and tensile strength, are derived, with few exceptions, from Miller's Chemistry.
The conductivity for heat is that given by Calvert and Johnson. The results obtained by Wiedemann and Franz differ widely from these.
For electric conductivity, Mathiesson's results, which differ from those of Becquerel, are employed.
The fusing-points are those given by Professor P. H. Van der Weyde.

* Heat-conducting power of marble..... 2.34
Heat-conducting power of porcelain..... 1.22
Heat-conducting power of brick earth..... 1.13

b. Broken stone around and beneath the wooden ties of a railway.

3. (*Glass.*) The technical name for the molten glass in order for blowing or casting.

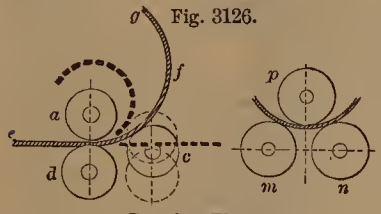
4. The effective power of the guns of a vessel expressed in the sum of the weights of the solid shot.

5. (*Founding.*) The workman's term for cast-iron.

Met'al-bend'ing Ma-chine'. Sheet-metal, such as tin-plate or boiler-iron, is bent into the cylindrical form by passing between rollers.

For the smaller descriptions of work the machine consists of two cylindrical rollers, *a* and *d*, geared to run together, and a third roller *c* which is capable of vertical adjustment. The metal is moved by the carrying rollers *a* and *d*, and, on striking the surface of the roller *c*, is bent up so as to pass over the same. As this bending occurs in an equal degree at every point of the sheet of metal, the result is that it assumes a circular sweep, the radius of which depends upon the position of *c*. In the central position, the sheet would assume the shape *e f g*, and, when *c* is more raised, say to the upper position, the plate would follow the dotted circle, the radius of which is much less. When the bending-cylinder *c* is thrown out of level, the sheet is thrown into a conical form.

Fig. 3126.



Bending Plates.

In the machine for bending plates the rollers *m n* are not necessarily in contact, and the regulation for different curvatures is by vertical adjustment of the upper roller *p*. The bending of sheet-metal for stove-pipes, chimneys, tin-ware, plow-mold boards, etc., is similar in principle.

Machinery is also used for bending skelps for tubes and gun-barrels; and for twisting strips into coils for gun-barrels.

Some articles are preferably bent into form by a stamping action.

Tubes are bent while filled with solder or resin, which allows them to assume a curve without puckering or disturbing the true circular section. By this mode the curved tubes of wind-instruments are made.

Met'al-fur'ni-ture. (*Printing.*) The metallic portion of the pieces used in filling up blanks, etc., in chases.

It includes reglet, side sticks, head and foot sticks, *quotation furniture* (hollow pieces of metal used to fill up blank spaces), and hollow quadrats. It is convenient to have reglet, etc. ready cut into lengths, varying from 18 to 120 or 130 ems. See FURNITURE.

Met'al-gage. One for determining the thickness of sheet-metal. A sheet-metal gage.

Met'al-ine. A compound for journal-boxes of metal, metallic oxide, organic matter, reduced to powder and compounded with wax, gum, or fatty matters. See JOURNAL-BOX.

Me-tal'lic Ba-rom'e-ter. One as contradistinguished from an instrument in which a fluid is employed. Also known as a *holosteric* barometer. Vidi invented the diaphragm form. (See ANEROID.) Bourdon invented the bent-tube form; a flattened, curved, exhausted tube, one end of which is fixed and the other geared to an index-pointer which traverses a graduated arc. Changes of pressure of the atmosphere affect the curvature of the tube, and so move the finger. See BOURDON BAROMETER.

Me-tal'lic Car'tridge. One in which the charge is contained in a metallic capsule, in contradistinction to the paper cartridge. See CARTRIDGE.

Me-tal'lic Chair. A chair of iron slats or wires interwoven, or of cast portions secured by rivets or screw-bolts.

Used for parks, gardens, and auditoriums.

Fig. 3127.

Iron Chair.

Me-tal'lic Dust. Grains of metal for giving a metallic luster to wall-paper, shell-work, lacquered ware, and for other purposes. It was first made by John Hautsch of Nuremberg (1595–1670). It is prepared by sifting the filings of different metals, washing them in a strong lye, and then placing them on a metallic plate over a strong fire, where they are continually stirred till their color is altered. Those of tin acquire by this process shades of gold color, with a metallic luster; copper, shades of flame color; those of iron or steel become blue or violet; those of tin or bismuth appear of a bluish-white color. The dust is then put through a flatting-mill, having polished steel rollers.

Me-tal'lic Pack'ing. Piston-packing consisting of a ring or several rings of iron or other metal, sometimes cast so as to possess elasticity in themselves, or sometimes cut into segments and pressed against the interior of the cylinder by springs, so as to form a steam-tight contact. See PISTON-PACKING.

Me-tal'lic Pa'per. Paper for memorandum-books, adapted to take an indelible mark from a leaden or pewter pencil. The paper is surfaced with a solution of lime, whiting, and size.

Me-tal'lic-tis'sue Loom. A loom for weaving with metallic threads, as in making gold and silver lace, braid, etc., entirely of metal, without any mixture of silk or other threads.

The wire is wound on hollow metallic bobbins, which are heated by the introduction of red-hot pieces of metal, and then allowed to cool, thus annealing the wire. The warp-threads (or wires) are then placed in the loom in the usual way. The weft must be somewhat finer than the warp, and a shuttle somewhat heavier than in silk weaving is used.

These looms are also used in making tissues in which the warp is of silk or thread and the weft of gold or silver wire or silk thread covered with a flattened silver wire which has been gilt.

Me-tal'lo-chrome. A coloring of metals by means of galvanism. It is an invention of Nobili, and consists in depositing thin films of a metal on metallic bodies by means of a galvanic battery, so as to form a number of rings. As the deposited rings — called, after the inventor, Nobili's rings — are not everywhere of the same thickness, they produce elevations and depressions, which, though not visible

to the naked eye, nevertheless cause a refraction of the rays of light, thus giving rise to the formation of the same colors that are seen in thin films of varnish, fissures in the ice, on window-glass that has been partially decomposed by atmospheric action, in soap-bubbles, pearls, and which also show themselves very beautifully in heating bismuth and other fusible metals.

"A saturated solution of acetate of lead is prepared and placed in a horizontal trough. Three or four battery cells are required. A steel plate is laid in the solution with its polished face upward, and is connected with the copper of the electro-battery. If a wire be connected with the zinc end of the battery and held over the steel plate in the solution, a series of circles in brilliant colors arises at the spot immediately beneath the wire, and expands and spreads like the circles when a stone is thrown into a pond. Silver-blonde is the first color; then fawn-color, followed by different shades of violet, indigo, and blue, lake, bluish-lake, green, and orange, greenish-violet, and passing through reddish-yellow to rose-lake, which is the last color in the series.

According to the shape of the metal into which the current enters, — be it a point, a slip, a cross, a concave or a convex disk, — so is the form of the colored figure varied. If, in addition to this, a pattern in card or gutta-percha is cut out and interposed between the two surfaces, the action is intercepted by the portions not removed, and the design is produced on the steel plate in colors that may be greatly varied, according to the duration of the experiment. The different colors are due to the different thicknesses of the films of peroxide of lead." — C. V. WALKER.

Met'al-log'ra-phy. 1. A process invented by Abate, in 1851. It consists in printing from wooden blocks upon metallic surfaces, so as to produce imitations of the grain of the wood. A veneer of wood is wetted with a solution of hydrochloric or sulphuric acid, and is then impressed upon the metal so as to cause the deposition of a colored metallic oxide.

Or the impression is taken on muslin, which is then in a condition to transfer it to the metal under pressure.

2. A substitute for lithography in which metallic plates are substituted for the lithographic stone. Kocher and Houssiaux of Paris use a surface of tin-foil backed by an alloy of lead and antimony, and strained around a roller which thus becomes the pressure and printing roller. The Exhibition of 1862 in Paris showed several varieties of this art, which, in one of its branches, is closely allied to the calico-printing by copper rollers of raised design.

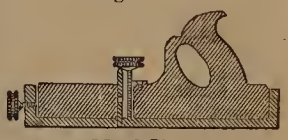
Met'al-lur'gy. The art of separating metals from their ores or from impurities: *smelting, reducing, refining, alloying, parting, plating,* etc. See under the following heads: —

Æthiop's mineral.
Affinage.
Aich's metal.
Albata.
Alloy (varieties, see ALLOY).
Altar.
Altinear.
Aluminium.
Aluminium-bronze.
Amalgam.
Amalgamating zinc-plates.
Amalgamator.
Amalgam-varnish.
Ammonium.
Annealing.
Annealing-oven.
Annealing-pot.
Anti-friction metal.
Antimony.
Argentan.
Argentine.
Argentometer.
Arsenic.
Assay-balance.
Assay-furnace.
Assaying.
Aurum musivum.
Autogeneous soldering.
Babbitt-metal
Ball-vein.
Barium.
Bath-metal.
Bean-shot.
Bear.
Bell.
Bessemer-process.
Biddery.
Billon.
Bing.
Bismuth.
Black-flux.
Black-plate.
Black-tin.
Blanched copper.
Blanching.
Blazing-off.
Blister-steel.
Block-furnace.
Bloom.
Bloom-steel.
Blow-pipe.
Blue-metal.
Bluing.
Book.
Boshes.
Bottoms.
Box-metal.
Brake-sieve.
Brass.
Brass-foil.
Brassing.
Brass-powder.
Brazing.
Bronzing.
Browning.
Bucking.
Bucking-iron.
Buddle.
Bull-dog.
Burdon.
Burning.
Burning-house.
Button.
Cabbling.
Cadmium.
Calamine.
Calcination.
Calciner.
Calcium.
Calebasserie.
Cannon-metal.
Capellina.
Capsule.
Caracoli.
Case-hardening.
Casting.
Cast-steel.
Caxon.
Cazo.
Cement.
Cementation.
Cerium.
Chafery.
Charge.
Chat-roller.
Chats.
Chill.
Chill-hardening.
Chimming.
Chlorine process for extracting gold.
Chromium.
Cinder.
Cliché.
Clincher.
Clinker.
Clinquant.
Coating metals with metals.
Cobalt.
Cobbing.
Cock-metal.
Cold-blast.
Cold-hammering
Col-rake.
Columbium.
Concentrator. Ore
Condenser.
Convertor.
Copper.
Copper-furnace.
Cradle.
Crevet.
Crucible.
Crucible-tongs.
Crusher. Ore and stone
Crystallized tin-plate.
Cupellation.
Cupello.
Cupola.
Cuttings.
Damascus iron
Damascus twist.
Damask.
Damaskeening.
Damask-steel.
Dam-plate.
Dead.
De-silvering.
De-sulphurizing ore.
Dilluing.
Dipping.
Dolly.
Double d'or.
Dradge.
Dross.
Dry-gilding.
Dutch gold.
Electro plating.
Electrum.
Eliquation.
Estufa process of extracting silver.
Fagot.
Fandon.
Fauld.
Fettling.
Files. Tempering
Fining-pot.
Fixing.
Float.
Floran.
Florence leaf.
Flosh.
Floss.
Floss-hole.
Flux.
Foil.
Foyer
Framing.
Frosted metal.
Fulguration.
Furnace.
Fusible alloy.
Galvanizing-iron.
Ganister.
German-chest.
German-silver.
German-steel
Gilding.
Glass-silvering
Gold.
Gold and silver by lead-bath. Extraction of
Gold-beater's skin.
Gold-chlorinating.
Gold. Electro process for extracting
Gold-leaf.
Gold-shell.
Gold-size.
Gold-varnish.
Gold-washer.
Granulated steel.
Griddle.
Gun-metal.
Hammer-hardening.
Hardening.
Hearth.
Hearth-ends.
Horn.
Hot blast.
Hotching-tub.
Hushing.
Hutch.
Hydro-metallurgy.
Ilmenium.
Ingot.
Iridium.
Iridosmine.
Iron.
Iron-chamber.
Iron with copper. Coating
Jagging-board.
Jigger.
Jigging-machine.
Keeve.
Knockings.
Labyrinth.
Lacquer.
Ladle.
Lamero.
Latten.
Launder.
Lead.
Lead-bath for extracting gold and silver.
Lead from silver. Separating
Leaf-metal.
Lightening.
Limp.

Lined gold.
Liquation.
Litharge.
Lithium.
Lobbing.
Long-tom.
Loobs.
Lool.
Loup.
Lustering.
Magistral.
Magnesium.
Malleable iron.
Malleable cast-iron.
Manganese.
Manheim-gold
Matrix.
Matt.
Mercury.
Mercury-gatherer.
Metallic dust.
Metallochrome.
Metallography.
Metallurgy.
Metals.
Metals with metals. Coating
Meteor-steel.
Mill.
Minargent.
Mock-gold.
Mock-platinum.
Mock-silver.
Moire-metallique.
Molybdenum.
Mosaic gold.
Muntz's metal.
Natural steel.
Nickel.
Nickel-plating.
Niobium.
Ore-calcining.
Ore-concentrator.
Ore-crusher.
Ore-grinding.
Oreide.
Ore-mill.
Ore-separator.
Ore-stamp.
Or-molu.
Oroide.
Orsedew.
Osleon-iron.
Osmium.
Oxidizing-ore.
Pack.
Packfong.
Palladium.
Pan.
Parting.
Patio-process.
Pattinson's pots.
Pelopium.
Percussion-sieve.
Percussion table.
Petong.
Pewter.
Pig.
Piling.
Pina.
Pinchbeck.
Plating.
Platinum.
Plomb-brut.
Plush-copper.
Pocket.
Poling.
Potassium.
Pot-metal.
Prill.
Prillion.
Prince Rupert's metal.
Puddled-steel.
Puddling.
Puddling-furnace.
Pug-tub.
Quartation.
Quartz-crusher.
Quartz-liquefier.
Quartz-mill.
Queen's metal.
Quenching.
Quicksilver.
Rabble.
Rack.
Ragging.
Refinery.
Refining-hearth.
Regenerating-furnace.
Regenerator.
Regulus.
Repoussé-work.
Retort.
Rhodium.
Roasting.
Roasting-furnace.
Rocker.
Roll
Rondle.
Ruff-wheel.
Ruthenium.
Sand-washer.
Scissel.
Scoria.
Screening-machine.
Semilor.
Separator.
Shaking.
Shear-steel.
Sheathing-metal.
Sheet-iron.
Sheet-metal.
Shoe.
Shot-metal.
Silicium.
Silver.
Silver from lead. Separating
Silvering.
Silver-mill.
Silver-plating.
Silver-powder.
Sizing-apparatus.
Skelp.
Slag.
Slakin.
Sleeping-table.
Slimes.
Slime-pit.
Sludge.
Smeddum.
Smelter's fume.
Smelting.
Sodium.
Solder.
Spalling.
Speculum-metal.
Spelter.
Sponge.
Stamp.
Stamp-head.
Steel.
Steely iron.
Sterro-metal.
Strake.
Strip.
Strontium.
Sublimation.
Sullage.
Sweeping-table.
Sweep-washings.
Taggers.
Tain.
Tasting-hole.
Temper.
Tempering.
Test.
Tilted steel.
Tin.
Tin-foil.
Tinning-iron.
Tin-plate.
Tin-scraps. Utilizing
Tiusel.
Titanium.
Tombac.
Torta.
Tossing.
Touch-needle.
Touchstone.
Tula-metal.
Tungsten.
Tutania.
Tutenag.
Tying.
Tyup-plate.
Type-metal.
Uranium.
Vanadium.
Vanning.
Vat.
Vermeil.
Walled area.
Washer. Gold
Washing-tablo.
Water-bosh.
Welding.
White-copper.
White-lead.
White-tombac.
Wire-temperiug.
Wolfram.
Wootz.
Yellow metal.
Zinc.
Zinc-white.
Zirconium.

Met'al-plane. A form of plane for facing soft metal plates by taking a fine shaving therefrom. Planing-machines of various kinds plane the backs of stereotypes and electrotypes. The angle of the plane with the sole is adapted to the hardness of the metal being worked.

Fig. 3128.



Metal-Plane.

Met'al-saw. A fine-toothed, hard, steel saw stretched in a frame and used for sawing metal. A *hack-saw.*

Met'al-work'ing Tools and Ma-chines', etc. See under the following heads: —

Agate.
Ancony.
Angle-gage.
Arbor
Auger-twister.
Babbiting-jig.
Backing-up.
Ball.
Balling-tool.
Bar-cutter.
Barrel-setter.
Bar-shear.
Beaded wire.
Beam.
Bear.
Bell.
Bench-drill.
Bench-shears.
Bending-machine.
Bending metal plates.
Billeting-roll.
Binder-frame.
Bolster.
Bolt cutter.
Bolt-heading machiue.
Bolt-machine.
Bolt-screwing machine.
Bolt-threader.
Boring-bar.
Boring-block.
Boring-machine.
Boring-mill.
Boring-table.
Boring-tool.
Boss.
Box-beam.
Boxes. Machines for making metal
Brace.
Breaking-down rollers.
Broach.
Broad.
Buckled plate.
Burning.
Burnisher.
Burr-cutter.
Bush.
Bush-extractor.
Calipers.
Carbon tool-points.
Card-grinding machine.
Center-chisel.
Center-gage.
Centering-machine.
Centering-tool.
Center-lathe.
Center-punch
Chamfering-tool.
Chaser.
Chasing-mallet.
Chasing-stake.
Chasing-tools.
Cherry.
Chipping-piece.
Chuck.
Clamming-machine.
Coining.
Colander.
Corner-punch.
Corrugated iron.
Corrugating-machine.
Counter-punch.
Countersink.
Cramp-drill.
Cranked tool.
Cut-nail machine.
Cutter.
Cutter-bar.
Cutter-grinding machine.
Cutter-head.
Cutting-out machine.
Cylinder.
Cylinder-boring machine.
Die.
Die-stock.
Dinged work.
Dog. Lathe
Dolly.
Drag-bench.
Drawing-bench.
Drawing-machiue.
Drawing-punch.
Draw-plate.
Drift.
Drill.
Drilling-machine.
Drive.
Driver.
Drop-press.
Expanding-mandrel.
Expanding-reamer.
Eyelet-machine.
Eyelet-punch.
Fagot.
Feather
File.
File-carrier.
File-cutting machine.
File-stripper.
Filigree.
Filing-block.
Filing-machine.
Finishing-rolls.
Fish-hooks. Machine for making
Flanging-machine.
Flatting-mill.
Flogging-chisel.
Fluting-cylinder.
Fly-punching press.
Folding-machine.
Forging-apparatus.
Forging-metals.
Gage.
Gear-cutter.
Hammer (varieties, see HAMMER).
Hanger.
Hanging-tool.
Heading-tool.
Hoe-blank machine.
Hook-tool.
Horseshoe-machine.
Horseshoe-nail machine.
Housing.
Hub.
Hydraulic punch.
Jam-nut.

Jim-crow.
Journal.
Journal-bearing.
Key-seats. Machine for cutting
Knurling.
Laminating-machine.
Lap.
Larget.
Lathe.
Lead-pipe.
Lead-shaving.
Leveling-block.
Lever-punch.
Lubricator.
Machine-tool.
Mandrel.
Marking-machine.
Metal-bending machine
Metal-drawing machine.
Mill.
Milling.
Milling-machine
Milling-tool.
Mold.
Mold-blocking machine.
Molding.
Mowing-machine grinder.
Muck-roll.
Mullar.
Nail-head tool.
Nail-machine
Nail-plate clamp.
Nail-plate feeder.
Nail-plate shears.
Needle.
Needle-making machine.
Nippers.
Nurling.
Nut.
Nut-bar.
Nut-lock.
Nut-making machine.
Nut-planer.
Nut-tapping machine.
Oil-can.
Oiler.
Palier-glissant.
Pass.
Pig-iron breaker.
Pillow-block.
Pin.
Pin-machine.
Pipe-cutter.
Pipe-driver.
Pipe-threading machine.
Pipe-wrench.
Planchet.
Planer.
Planer-center.
Planing-machine.
Planishing-rollers.
Plant.
Plate-bending machine.
Plate-iron girder.
Plate-shears.
Pressing metals.
Puddling-roll.
Punch.
Punch and shears.
Punching-bear.
Punching-machine.
Rail-bender.
Rail-punch.
Rail-straightening machine.
Ratchet-brace.
Reamer.
Reeding.
Rifling.
Rivet.
Rivet-hearth.
Riveting-machine.
Riveting-tools.
Rivet-machine.
Rolling-metals.
Rolling-mill.
Routing-tool.
Rove.
Scissel.
Scobs.
Screw.
Screw-cap.
Screw-cutter.
Screw-cutting lathe.
Screw-cutting machine.
Screw-making machine.
Screw-molding.
Screw-plate.
Screw-threading machine.
Screw-wrench.
Set.
Set-up.
Shafting.
Shaft-straightener.
Shaping-machine.
Shearing and punching machine.
Sheet-iron.
Sheet-metal bender.
Sheet-metal cutter and folder.
Sheet-metal die.
Sheet-metal folder.
Sheet-metal forming machine.
Sheet-metal polisher.
Sheet-metal scourer.
Sheet-metal straightener.
Shim.
Shingler.
Shingling-hammer.
Shot-making.
Shrunk-on.
Skelp.
Skelp-bender.
Sledge.
Slide-rest.
Slitting-machine.
Slotting-machine.
Snap.
Soldering.
Soldering-iron.
Spherical-shot machine.
Spike-machine.
Spinning-metal.
Spring-coiling machine.
Spring-polisher.
Spring-tester.
Squeezer.
Stamping-metals.
Staple-making machine.
Staving-metals.
Stencil-cutter.
Straightening-metals.
Swage.
Swage-block.
Swaging-machine.
Swaging-metals.
Swarf.
Swing-tool.
Tap.
Tap-plate.
Teeming-punch.
Templet.
Thumb-nut.
Tin-lining pipe.
Tire-upsetting machine.
T-iron.
Tool-holder.
Triblet.
Tube.
Tube-cutter.
Tube-making.
Tube-sheet cutter.
Turning-lathe.
Turning-mill.
Turning-tool.
Upsetting-machine.
Upsetting-press.
Vise.
Washer.
Washer-cutter.
Web.
Welding-machine.
Welding-metals.
Wheel-cutting machine.
Wheel-molding machine.
Wheel-press.
Wheel-quartering machine.
Wire-cloth crimper.
Wire-cloth loom.
Wire-cloth painter.
Wire-covering
Wire-covering machine.
Wire-drawing.
Wire-gage.
Wire-pointer.
Wire-rope.
Wire-straightener.
Wire-tempering.
Wire-twister.
Wordle.
Wrench.

Met'a-mor'pho-scope. A toy having an opening at which the pictures on several belts are presented, the respective belts having head, body, and

Fig. 3129.

Metamorphoscope.

leg portions of figures. The belts are of different lengths, so as to mismatch the sections as they are revolved.

Me'te-or'o-log'i-cal In'stru-ments. See under METER for list; including BAROMETER, THERMOMETER, HYGROMETER, RAIN-METER, etc.

Me'te-or-om'e-ter. (*Telegraphy.*) An apparatus for receiving, at a local station, transmitting to a central station, by telegraph-wires, and there recording, the direction and velocity of the wind, condition of the barometer and thermometer, amount of rainfall, etc.

Stephen Chester of Elizabeth, New Jersey, patented in 1862 a telegraphic meteorometer which records at frequent intervals by a single wire, from as many instruments as may be desired, and at any distance; the purpose being to collect reports for the signal service. A clock-work mechanism at the sending station throws the wire alternately into connection with a registering anemometer, vane, barometer, thermometer, etc., at such intervals of time as may be decided upon.

The anemometer is of the windmill kind, and its shaft carries a tooth which breaks an electric circuit at each revolution. The rapidity of electric pulsations, therefore, indicates the velocity of the wind. The motion of the vane opens and closes various circuits as it traverses the circle, and so records itself.

Thermometric and barometric registration is obtained by making the mercury column a part of an electric circuit. As the columns rise and fall they make connection with a greater or less number of wires, which transmit their report to the line-wire as their turn comes. Other connections are obvious. The operations are to be conducted from the receiving station, where are also the recording instruments which register the indications of the various sending instruments, as they are consecutively and automatically connected by switch with the telegraphic wire.

Me'te-or'o-scope. An instrument used for taking angles, and making measurements of the heavenly bodies.

Me'te-or-steel. An alloyed steel which has a wavy appearance, resembling the Damascus steel.

An alloy of zinc, 80; nickel, 16; silver, 4 = 100, is placed in a black-lead crucible, covered with charcoal, and melted. It is rendered friable by pouring it into cold water, is reduced to powder, called *meteor-powder*, and is added to steel in a crucible in the following proportions: —

Blister steel, 28 pounds; meteor-powder, 10 ounces; chromate of iron, 8 ounces; charcoal, 1 ounce; quicklime, 2 ounces; porcelain-clay, 3 ounces.

These materials are melted in the usual manner, cast into an ingot, drawn into bars, and treated as cast-steel.

The wavy appearance may be farther brought out by washing the surface with dilute nitric acid; acid 1 part, water 19 parts.

Me'ter. (Fr. *Mètre.*) 1. The French unit of measurement of length, equal to 39.3708 inches, or 3.2809 feet. The $\frac{1}{10000000}$ part of the quadrant of the earth measured on a meridian. See METRIC SYSTEM.

One of the original set of iron meters, made in France, is now at the Coast Survey Museum in Washington, where are also the brass standard yard of England and many other standard measures and weights, home and foreign.

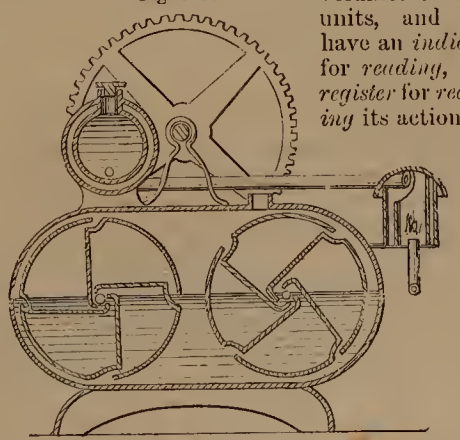
The new international meter-measure was cast, in the presence of the commission at Paris, in the laboratory of M. Sainte-Claire Deville. It consists of an alloy of platinum and iridium. Nine kilogrammes of platinum and one kilogramme of iridium were melted by means of the oxyhydrogen gas blowpipe. This process took three quarters of an hour; the molten mass was then let off into a mold made, like the crucible, from a block of limestone, whose inner surface was burnt to lime in consequence of the heat. The metal did not lose its luster in cooling, and was afterward shaped, tested, and graduated.

2. A measuring instrument. See under the following heads: —

Acetimeter.
Acetometer.
Acidimeter.
Acoumeter.
Actinometer.
Aeromcter.
Air-meter.
Airometer.
Air-thermometer.
Alcoholmeter.
Aleurometer.
Alkalimeter.
Altarimeter.
Altometer.
Anemometer.
Angle-meter.
Angulomcter.
Anthracometer.
Antimeter.
Apomecometer.
Areometer.
Argentometer.
Arithmomcter.
Astrometer.
Atmidometer.
Atmometer.
Autometer.
Balance-electrometer.
Barkometer.
Barometer.
Barometrical aeriometer.
Bathometer.
Bdelometer.
Blanchimeter.
Blast-meter.
Calorimeter.
Capillarimeter.
Carbonometer.
Cardiometer.
Cathetometer.
Chartometer.
Chlorometer.
Chromiometer.
Clinometer.
Colorimetcr.
Couchometer.
Conchylometer.
Craniometer.
Cupel-pyrometer.
Current-meter.
Cyanomcter.
Dasymcter.
Declinometer.
Decolorimcter.
Deflectometer.
Dendrometer.
Densimeter.
Diagomcter.
Diaphonometcr.
Diastimeter.
Drop-meter.
Drosometer.
Dry-meter.
Ductilimeter.
Durometer.
Dyactinometer.
Dynametcr.
Dynamometer.
Echometer.
Elaiometer.
Elateromcter.
Electrical meter.
Electrometer.
Endosmometcr.
Entomometer.
Eriometer.
Esthesiometer.
Eudiometer.
Evaporameter.
Fluid-meter.
Focimcter.
Galactometer.
Galvanometer.
Gas-meter.
Gasometer.
Gas-thermometer.
Goniometer.
Grain-meter.
Graphometer.
Gravimeter.
Halometer.
Harmonometer.
Heliometer.
Hemadrometer.
Hemadynamometer.
Holomcter.
Holosteric barometer.
Horometer.
Hydro-barometer.
Hydrometer.
Hygrometer.
Hypsometer.
Inclinometer.
Indigometer.
Inductometer.
Klinometer.
Lactometer.
Limestone-meter.
Liquid-meter.
Litrameter.
Long-range barometer.
Lucimeter.
Maerometer.
Magnetometer.
Manometer.
Marine barometer.
Maximum barometer.
Mecometer.
Megameter.
Meteorometer.
Metrochrome.
Metrograph.
Metrometer.
Metronome.
Metroscope.
Micrometer.
Micronometer.
Minimum barometer.
Mountain-barometer.
Murometer.
Myo-dynamometer.
Nauropometer.
Nephelodometer.
Nephclorometer.
Nepheloscope.
Nilometer.
Nitrometer.
Odometer.
Œnometer.
Oleometer.
Ombrometer.
Operameter.
Ophthalmometer.
Opthalmodiastimeter.
Opsiometer.
Optometer.
Ozonometer.
Panta-chronometer.
Pantamometer.
Pantometer.
Pediment-barometer.
Pedometer.
Peirameter.
Pelvimeter.
Photograph-meter.
Photometer.
Piezometer.
Pirameter.
Planimeter.
Planometer.
Platometer.
Pleximeter.
Pluviameter.
Pneumatometer.
Polaristrobometer.
Polymeter.
Prism-spherometer.
Procheameter
Psychrometer.
Pthongometer.
Pulmometer.
Pulp-meter.
Pyrheliometer.
Pyrometer.
Radiometer.
Rheometer.
Rhysimeter.
Rotary meter.
Saccharometer.
Salinometer.
Scismometer.
Self-registering barometer.
Sonometer.
Sphereometer.
Sphygmomcter.
Spirit-meter.
Spiritometer.
Spirometer.
Stadimeter.
Steam-power meter.
Stereometer.
Stethometer.
Stylometer.
Submarine thermometer.
Sympiesometer.
Tachometer.
Telemeter.
Thallasometer.
Theodolite-magnetometer.
Thermo-barometer.
Thermometer.
Tithonometer.
Tonomcter.
Tradiometer.
Trechometer.
Tribometer.
Tympanomcter.
Udometer.
Urinometer.
Velocimeter.
Viatomcter.
Voltameter.
Water-meter.
Wet-meter.
Wheel-barometer.
Zygmosimcter.
Zymometer.

The terms *meter*, *register*, *counter*, *indicator*, are somewhat irregularly used, but are not exact synonyms. An *indicator* makes audible or visible notice of results or condition. A *register* records. A *meter* measures distance, capacity, power, etc., giving results usually in volumes or other units, and may have an *indicator* for *reading*, or a *register* for *recording* its action.

Fig. 3130.



Meter-Wheel.

Me'ter-wheel. One used in connection with gas and liquid meters and air-carbureting machines.

In the former, it is driven by the flow of gas whose volume it measures; and in the latter case it is usually employed to induce a flow of air through the hydrocarbon liquid, and performs the function of a blower. It has usually several chambers, and when measuring gas, is submerged above its axis in water, in the chamber wherein it rotates. The chambers in the wheel are of known capacity, and the revolutions are registered upon dials. In the gas-meter, the gas passes in at the hollow trunnion, and passes from the central pipe to each chamber in turn. As the gas fills the chamber it rises, and, when filled, its lip rises above the surface of the water and discharges its gas into the upper part of the containing-case. As the chambers of the drum pass over, they again fill with water. See GAS-METER.

Mete-stick. (*Nautical.*) A measure used in storing cargo, in order to preserve proper levels.

Met'o-pe. (*Architecture.*) The space between the triglyphs in the frieze of the Doric order.

Me-tren'chy-tes. (*Surgical.*) A syringe for injecting medicated liquids into the uterus.

Met'ric Sys'tem. The system adopted by the French convention in 1795, in which all measures of length, area, capacity, and weight are based upon the length of a quadrant of the meridian measured between the equator and the pole.

The origin of the system is due to the government of Louis XV., who named a commission to investigate the best means of reforming the great diversity of weights and measures then used in the different cities and provinces of France. These investigations were continued under his successor, and in 1790 Talleyraud distributed among the members of the National Assembly a proposal for the establishment of a single and universal standard of measurement.

A committee from the Academy of Sciences, Borda, Lagrange, Laplace, and Condorcet, all men of the highest scientific eminence, were appointed under a decree of the Assembly to report upon the selection of a natural standard. They proposed, in their report, that one ten-millionth part of a quarter circumference of the globe at the meridian of Paris should be taken as the unit of lineal measure.

This is undoubtedly a more definite standard than that of the English and American systems, which are based upon the length of a pendulum beating seconds in the latitudes of London and New York respectively. It may be remarked that the English and American determinations of the foot and yard from these sources differ slightly, though not enough to affect any practical result. The values of the meter are, in English inches, 39.37079; in American inches, 39.368. The values of the metric measures in the following tables are compared with those of the English yard.

Van Swinden was one of the commissioners for settling the basis of the system, and gives a lengthy description, from which we derive the following: —

"The standard is founded upon the basis of the quadrant of the earth, being the part of the terrestrial meridian contained between the equator and the north pole. The 10,000,000th part of this quadrantal arc was adopted to be the linear measuring unit, which they called "mètre," applying it equally to superficial and solid measures, taking for the unit of the former the square of the decuple, and for that of the latter the cube of the tenth part of the meter. They chose also for the measuring unit of weight, the quantity of distilled water equal in bulk to the same cube at a certain temperature. They also decided that the multiples and sub-multiples of each kind of measure, whether of weight, capacity, surface, or length, shall be always taken in the decimal or decuple proportion, as the most simple, natural, and easy for calculation, according to the system of numeration which all Europe has used for many centuries.

"The Institute (National Institute of France) ordered a new and actual measure of the whole arc of the meridian extending the whole length of France, from Dunkirk on the north to Barcelona in Spain, and passing Paris, an extent of almost 10°. The measurement of this arc employed Mechain and Delambre for several years. They employed rods of platinum of 12 feet in length for measuring the bases; and whole circles, accurately made, for taking the angles to 10ths of seconds, by repeating the measures in different parts of the circumference, and taking the mediums of the whole. The precision with which the angles were observed is such that, out of 90 triangles which connect the extremities of the meridional arc, there are 36 in which the sum of the 3 angles differs from its proper quantity by less than 1 second; that is, in which the error of the three angles taken together is less than 1 second; there are 27 triangles in which this error is less than 2 seconds; in 18 others it does not amount to 3 seconds; 4 are under 4 seconds; and the remaining 3 are under 5 seconds.

"Every care was taken to support and dispose the platinum rods properly in measuring the bases. The extremities of the rods were never brought into contact; an interval being left, which was measured by a tongue of platinum, sliding from the end of one of the rules and carrying a vernier and microscope. The corrections or allowances for differences of temperature, for obliquities of the line actually measured, and for the elevation above the level of the sea, were also attended to and allowed for. One rod was kept unemployed for a module or standard at 10° Reaumur or 54° Fah."

In deducing the length of the quadrant of the meridian, the arc measured by Bouguer and La Condamine in Peru, in 1736, was taken as an element. More recent and extended measurements at different points of the earth's surface indicate that the data upon which the metric determinations were founded were inadequate for ascertaining the exact variations in curvature of this irregular ellipsoid at different latitudes, and that consequently the meter is not exactly what it should be, but 10,000,000 meters fall short, according to Sir J. F. W. Herschel, by 4,008 feet of measuring a meridional quadrant. This error, amounting to but $\frac{1}{2\,0\,8}$ of an inch to the meter, is disregarded.

As before observed, the meter is the basis of all measurements. From it are derived the following units: —

Of area; the *are*, — 1 square decameter.
Of capacity; the *liter*, — 1 cubic decimeter.
Of weight; the *gram*, — 1 cubic decimeter of water.

The names of the graduations below the unit are formed from the Latin, and above the unit are formed from the Greek, as follows, the unit being 1: —

Myria	10,000
Kilo	1,000
Hecto	100
Deka	10
	1
Deci	0.1
Centi	0.01
Milli	0.001

In each of the four classes, — length, area, capacity, and weight, — these prefixes indicate the character of the measure. Greek for multiples, Latin for fractions.

Measures of Length.

Millimètre (.001 mètre),	0.03937 inches.
Centimètre (.01 mètre),	0.39371 "
Déeimètre (.1 mètre),	3.93708 "
Mètre (unit),	39.3708 " or 3.2809 feet.
Dékamètre (10 mètres),	32.809 feet, or 10.9363 yards.
Hectomètre (100 mètres),	328.09 " 109.3633 "
Kilomètre (1,000 mètres),	1,093.63 yards, or 0.62138 miles.
Myriamètre (10,000 mètres),	10,936.33 " 6.21382 "

Table.

10 millimeters make	1 centimeter.
10 centimeters make	1 decimeter.
10 decimeters make	1 meter.
10 meters make	1 decameter.
10 decameters make	1 hectometer.
10 hectometers make	1 kilometer.
10 kilometers make	1 myriameter.

Measures of Area.

The unit of area is a square whose side is 10 meters. It is called an ARE, and is equal to 100 square meters.

Centiare (.01 are or square mètre),	1 1960 sq. yards=1,550 square inches.
Are (sq. décamètre and unit),	119 6033 sq. yards or 0.0247 acres=3.9536 p.
Decare (10 ares),	1,196.033 sq. yards or 0 247 acres=39.536 p.
Hectare (100 ares)	11,960.33 sq. yards or 2.471 acres=2 a. 1 r. 35.376 p.

Table.

100 centiares make	1 are.
10 ares make	1 decare.
10 decares make	1 hectare.

Measures of Capacity.

The unit for the measure of volumes is a cube whose edge is $\frac{1}{10}$ of the meter; that is, a cube whose edge is 3.937 inches. It is called a LITER, and is $\frac{1}{1000}$ part of a cubic meter.

Metric Denominations.			English Equivalents.		United States Liquid Measure.
Milliliter	0.001 of a liter	1 cubic centimeter	0.00704 gills	0.061027 cubic inches	0.27 fluid drams.
Centiliter	0.01 of a liter	10 cubic centimeters	0.0704 gills	0.610271 cubic inches	0.338 fluid oz.
Deciliter	0.1 of a liter	.1 cubic decimeter	0.704 gills	6.102705 cubic inches	0.845 gill.
Liter	1 liter	1 cubic decimeter	1.761 pts.	61.027052 cubic inches	1.0567 quart.
Decaliter	10 liters	10 cubic decimeters	2.201 galls.	610.270515 cubic inches	2.6417 galls.
Hectoliter	100 liters	.1 cubic meter	2.751 bus.	6,102.705152 cubic inches	26.417 galls.
Kilditer or stere	1,000 liters	1 cubic meter	27.512 bus.	61,027.051519 cubic inches	264 17 galls.

Table.

10 milliliters make	1 centiliter.
10 centiliters make	1 deciliter.
10 deciliters make	1 liter.
10 liters make	1 decaliter.
10 decaliters make	1 hectoliter.
10 hectoliters make	1 kiloliter or stere.

Weights.

The unit of weight is equal to $\frac{1}{1000000}$ part of the weight of a cubic meter of pure rain-water weighed in a vacuum. It is called a GRAM, and is equal to 15.432 grains Troy = .0352746 ounces avoirdupois, nearly.

METRIC DENOMINATIONS AND VALUES.			Equivalents in denominations in use.
Names.	Number of Grams.	Weight of what quantity of water at maximum density.	Avoir'pois.
Milligram	0.001	1 cubic millimeter	0.0154 gr.
Centigram	0.01	10 cub. millimeters	0.1543 gr.
Decigram	0.1	.1 cub. centimeter	1.5432 gr.
Gram	1	1 cub. centimeter	15.432 gr.
Dekagram	10	10 cub. centimeters	0.3527 oz.
Hectogram	100	1 deciliter	3.5274 oz.
Kilogram or kilo	1,000	1 liter	2.2046 lbs.
Myriagram	10,000	10 liters	22.046 lbs.
Quintal	100,000	1 hectoliter	220.46 lbs.
Millier or ton	1,000,000	1 cubic meter	2,204.6 lbs.

Table.

10 milligrams make	1 centigram.
10 centigrams make	1 decigram.
10 decigrams make	1 gram.
10 GRAMS make	1 decagram.
10 decagrams make	1 kilogram.
10 kilograms make	1 myriagram.
10 myriagrams make	1 quintal.
10 quintals make	1 millier or ton.

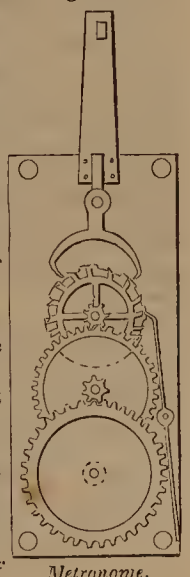
On the adoption of the metric system, the French also reformed their currency, abolishing the *livre* and *sous*, and adopting the *franc*, which it was decreed should weigh five grams, and be composed of 9 parts pure silver and 1 part alloy. It is divided into 100 centimes. This piece constitutes the basis of the French coinage.

The United States, however, led the way in a decimal currency.

The metric system, though adopted in 1795, was not fully carried into effect until 1840. It is now employed throughout a large part of Continental Europe, and seems in a fair way to be generally adopted at some not very distant day in the United States, where it may now be legally employed at the option of the parties interested.

Met'ro-chrome. A color-measurer. Invented by Field and described in his "Chromatograph." It consists of three hollow wedges of glass, of exactly the same angle and capacity, and accurately graduated on the edge to the same number of equal degrees. These wedges are so arranged between two screens that any portion of their tapering sides may be presented at will to an aperture through which a direct view may be had, or a ray of light thrown. The wedges are filled respectively with a yellow, a red, and a blue transparent liquid, each color being exactly the same in depth or intensity. It is obvious that, descending from the apex to the base of these wedges, the amount of color or the number of its atoms presented to the eye increases in proportion to the divergence of its sides.

Fig. 3131.



Metronome.

Met'ro-graph. An apparatus to be attached to a locomotive, indicating on a time-paper the speed with the number and duration of the various stoppages.

Me-trom'e-ter. (*Surgical.*) An instrument for measuring the size of the womb. A *hysterometer*.

Met'ro-nome. An instrument for beating and dividing the time in music. A musical time-keeper. Patented in England by John Mälzel, December 5, 1815.

It has a small pendulum which, being set in motion by clock-work, beats audibly a certain number of

times in a minute ; and this number may be altered by moving a sliding weight so as to give it the speed required.

In Fig. 3131, the verge-wheel is attached to a wheel having equal raised surfaces and depressions around its periphery, and these act on one end of a pivoted lever, whose other end is connected by a fine thread to an indicator attached to a spiral spring.

Met'ro-scope. (*Surgical.*) An instrument invented by M. Nauche, for listening to the sounds of the heart of the fetus in utero gestation. The extremity was suggested by the stethoscope of Laënnec, and is introduced through the vagina and applied against the neck of the uterus. It is used when the sounds and movements are imperceptible through the parieties of the abdomen.

Met'ro-tome. (*Surgical.*) An instrument like a bistoury caché, which is introduced into the cavity of the uterus, where the knife is unsheathed and cuts on withdrawing. Its purpose is to divide the neck of the uterus. See Thomas's "Diseases of Women." A *hysterotome.*

Mez-za-nine'. A low window occurring in attics and entresols.

Sometimes applied to an *entresol.*

A *mezzanine story* is a half-story ; one lower than the stories above and below it.

Mez'zo-ri-li-e'vo. The moderate prominence of a sculptured figure from the plane surface to which it is attached. It is also known as *demi* or *half-relief,* and is a grade between *alto-rilievo* or *high-relief,* and *basso-rilievo* or *low-relief.* See Rilievo.

Mez'zo-tint-en-grav'ing. The inventor of this art is believed to have been Colonel Ludwig von Siegen, a lieutenant-colonel in the service of the Landgrave of Hesse Cassel. Portraits executed by him exist, having the date of 1643. Prince Rupert gave so much attention to it, and was so instrumental in bringing it into favor, that he has been credited with the invention. Sir Christopher Wren has also been cited as the inventor, but his claims are antedated by Prince Rupert.

"Mr. Evelyn showed me the whole secret of mezzo-tinto, and the manner of it, which is very pretty, and good things done with it." — Pepys's *Diary,* November 1, 1665.

The process consists in passing over a plate of steel or copper with an instrument called a *cradle,* by which a burr is raised over every portion of the plate, which, if filled with ink by the printer, would make a black impression. On the surface thus prepared, the lights and middle tints are burnished or scraped away ; the burr being more or less perfectly removed, according to the gradation of light required. The plate is untouched in the parts intended for the darkest tint. The instruments used are the cradle or rocker, scraper, burnisher, roulettes. It is usual to etch-in the outlines of the design to form a guide in the operations of scraping and burnishing. A more extensive use of the etching process gives character and force to the work. The tools, cited above, are described under their respective heads.

Mi'ca. A mineral which cleaves into thin transparent plates. Known to miners as *glimmer.* It is the *lapis specularis* of Pliny, used in ancient times for window-panes.

The uses of mica in the mechanic arts are numerous. Among them may be cited, —

Windows for stoves and lanterns.

Chimneys for lamps.

Ground, as a lubricator and as a packing.

As a substitute for glass in spectacles, in protecting the eyes in various mechanical operations.

As a substitute for glass in silvered reflectors, in places where it will be exposed to heat, as in headlights, etc. (Marshall's patent.)

Mixed with varnish as a coating for wall-paper (Beck's patent), and in bronzing statuettes and other plastic articles.

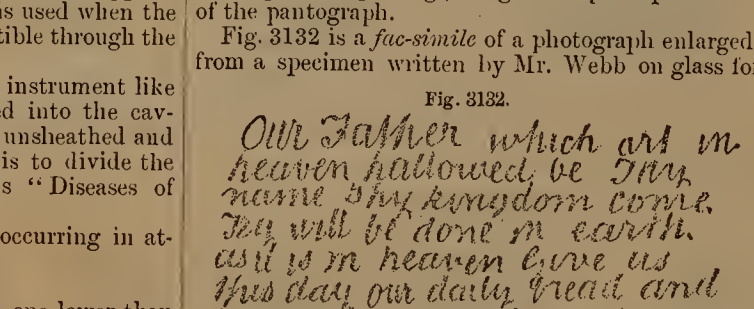
As a covering for roofs (Ditto's patent).

Mi'cro-cous'tic. (*Surgical.*) An aural instrument for collecting sounds for the partially deaf. An auricle or speaking-trumpet.

Mi'cro-graph. An instrument invented by Mr. Webb of London, for executing extremely minute writing and engraving ; its general principle is that of the pantograph.

Fig. 3132 is a *fac-simile* of a photograph enlarged, from a specimen written by Mr. Webb on glass for

Fig. 3132.


Our Father which art in
heaven hallowed be Thy
name Thy kingdom come
Thy will be done in earth
as it is in heaven Give us
this day our daily bread and
forgive us our trespasses as we
forgive them that trespass
against us and lead us not
into temptation but deliver
us from evil. Amen.

The Lord's Prayer (from a Micro-photograph of the original Writing on Glass, occupying the $\frac{1}{129654}$ of a Square Inch).

the United States Army Medical Museum. The glass slip also contains the following inscription in a larger writing : —

"Webb's Test. The Lord's Prayer. 227 letters in the $\frac{1}{294} \times \frac{1}{441}$ of an inch, or the $\frac{1}{129654}$ of a square inch, and at the rate of 29,431,458 letters to an inch, which is more than 8 Bibles, the Bible containing 3,566,480 letters."

The area within which the Prayer was written was micrometrically verified by Dr. J. J. Woodward, United States Army, who found that it and the above inscription were contained within a space $\frac{1}{75}$ of an inch square.

Mr. Webb claims that writing of this kind affords a test of microscopic power superior to that afforded by Nobert's Plates (which see), the finest of which he endeavors to prove have no real existence, but result from an optical delusion produced by the polarization of light. Dr. Woodward, however, says that the optical appearance of such of Nobert's bands as have never been resolved into separate lines by the highest powers yet attained are so similar to the others that it is unreasonable to doubt that they are ruled as stated by Nobert. He attributes the success of Nobert to the minuteness of the points employed by him, which appear to far exceed those of other artists, and are the result of a secret which he has hitherto kept to himself.

According to a statement made in 1862 by Mr. Farrants, president of the Microscopical Society, Mr. Peters has succeeded in writing the Lord's Prayer, so as to be distinctly legible, with sufficient magnifying power, within the space of $\frac{1}{3560000}$ of a square inch. The instrument employed was invented by him, and is termed the Micropantograph (which see).

Mi-crom'e-ter. An instrument used with a telescope or microscope to measure small distances, or the apparent diameters of objects which subtend very small angles. — Webster.

Micrometers are variously constructed. The field of the telescope may be provided with a graduated scale, or a metallic ring, or a diaphragm having parallel and intersecting spider-lines or fine wires.

The micrometer with a *graduated scale* is used for measuring distances by direct comparison.

The application of the micrometer to the telescope is credited by Whewell to Huyghens, Malvasia, and Azout. It was a great advance in the attempt to do by accuracy of measurement what had previously been attempted, and in part accomplished, by enlarging the instrument so as to enable the measurements of smaller arcs.

The first micrometer on record is that of Gascoigne of England, constructed about 1640, and used by him in measuring the diameters of the moon and some of the planets.

The inventor perished in the civil war, 1644. The instrument had nicely ground parallel edges of brass plate, and parallel hairs were substituted by the renowned Dr. Hooke.

Huyghens, about 1652, measured the diameter of a planet by inserting in the tube of the telescope, at the focus of the object-glass and eye-glass, a slip of metal which covered exactly the image of the planet, and then deduced the diameter by the breadth of the slip compared with the breadth of the field.

Malvasia, shortly after, employed a network of fine silver wire, making a *reticulated* or *filar micrometer*. The wires were stretched across a diaphragm in his telescope, crossing each other at right angles and dividing the field of view into squares of equal size.

Azout, a French astronomer, published an account of the micrometer in 1667.

Picard, another French savant, who died in 1684, was instrumental in the practical application of the micrometer to instruments. He early adapted the telescope to the measurement of angles, and determined with reasonable correctness the length of a degree, which he measured by means of an Odometer (which see).

Roemer, in 1678, suggested the *divided object-glass micrometer*, which was more perfectly adapted by Bouguer, seventy years afterwards.

Boscovich, in 1740, invented the *circular micrometer*, which was used by Lecaille in 1742, and Olbers, 1798, and improved by Frauenhofer.

Ramsden, about 1780, suggested the use of *cobwebs* as a fine filament substitute for wire. It has been credited to Troughton.

A substitute for the spider-line micrometer, over which it possesses many advantages, is formed of a thin plate of glass on which equidistant parallel lines are ruled by means of a diamond-point. Spider-lines are liable to become displaced or to become relaxed in consequence of the hygrometric conditions of the atmosphere, while the glass plate is permanent and unalterable.

Rochon invented the *double-refraction* or *prism micrometer*.

A filament of silk, a fiber of spun-glass, of melted sealing-wax, of asbestos, or a minute crystal of mezzolite, were successively suggested and employed. Wollaston adopted a platinum wire, drawn to extreme tenuity by inclosing it in a plug of silver, afterward removed by acid; this is illuminated by a ray of light which passes from a lamp along the horizontal axis, and is reflected by a small speculum upon the wire.

The wires of the Oxford heliometer (England) are illuminated by a voltaic current, which renders them red-hot.

Porro illuminates the wires by a thin vein of light perpendicular to the axis of the telescope, so as to make the wires silvery white in a dark field.

Brewster proposed to obtain micrometer lines by placing in the field of view the reflected images of a fixed or movable system of wires or of lucid disks attached to the side of the eye-piece.

The photographic micrometer is thus described by Sir David: —

"If a system of opaque or transparent lines be impressed upon the collodion photographically when reduced to the minutest size, from a system of large and sharply defined lines, we shall have the most perfect micrometrical scale that can be conceived; the portion of collodion that contains no nitrate of silver being as transparent as if the dark places were solid wires or metallic plates placed in the focus of the eye-glass."

See Pearson's "Practical Astronomy," Vol. II.; Brewster's "Philosophical Instruments."

Cavallo's micrometer is a small, semi-transparent scale of mother-of-pearl, about $\frac{1}{20}$ of an inch broad and divided by finely ruled lines. It is situated within the tube, at the focus of the eye-lens of the telescope, with its divided edge in convenient proximity to the image.

See under the following heads: —

Annular micrometer.	Micrometer-balance.
Circular micrometer.	Micrometer-microscope.
Cobweb micrometer.	Micrometer-screw.
Dioptric micrometer.	Mother-of-pearl micrometer.
Divided object-glass micrometer.	Photographic micrometer.
Double-image micrometer.	Position-micrometer.
Double-refraction micrometer.	Prism-micrometer.
Eye-piece micrometer.	Reticulated micrometer.
Filar micrometer.	Ring-micrometer.
Heliometer.	Scale-micrometer.
Linear micrometer.	Stage-micrometer.
Megameter.	Wire-micrometer.

Mi-crom'e-ter-bal'ance. Kenshaw's micrometer-balance, invented about 1842, consists of a beam or steelyard supported on a knife-edged fulcrum. Near one end of the beam a few threads are cut, on which is a wheel graduated to degrees, each of which corresponds to half a grain in weight. The coin is placed on the other end of the beam, and if of correct weight an index-bar points to zero on the wheel; but if it be light, the wheel is turned round, altering the leverage of the beam until it is in equilibrio. The degree to which the index-bar points shows how many half-grains the coin is short of its proper weight. The device may be adjusted to weigh half-sovereigns.

Mi-crom'e-ter-mi'cro-scope. The *micrometer-microscope* is used for reading and subdividing the divisions of large astronomical and geodetical instruments. (Webster.) Around the mural circle of the Washington Observatory are placed six micrometer-microscopes, with an acute cross of wires at their foci for reading angles less than 5′. Five revolutions of the micrometer are designed to measure 5′ upon the circle. The micrometer heads being divided into sixty equal parts, each division represents 1″ of arc.

Mi-crom'e-ter-screw. A screw attached to optical and mathematical instruments as a means for exact measurement of very small angles.

The great space through which the lever of the screw passes, in comparison with the longitudinal motion due to the pitch, affords the means for a positive motion which is imperceptible on the object moved, though appreciable in its results.

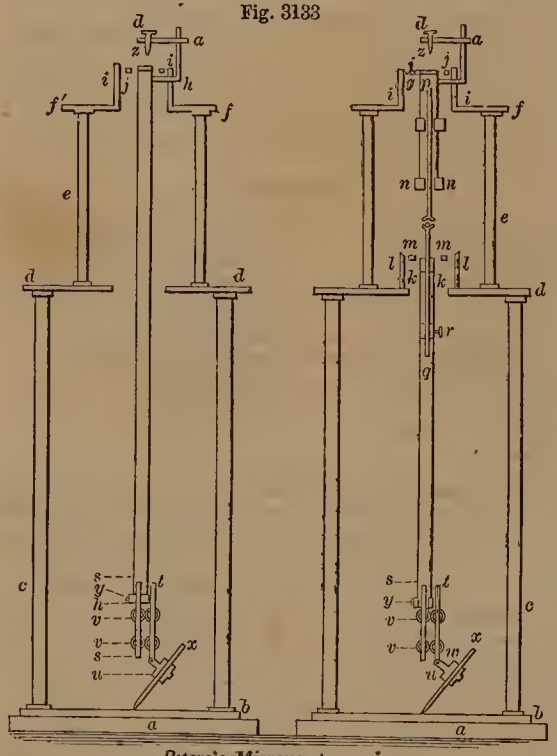
The head of the micrometer-screw being divided into sixty equal parts, and representing 1′ of arc, a revolution would be equal to 1°.

If the thread of a micrometer-screw in an instrument has 50 threads to an inch, and carries a pointer which traverses a graduated circle divided into 20 equal parts, the revolution of the micrometer-screw for a distance equal to one of the divisions will move the object to which the screw is attached $\frac{1}{1000}$ of an inch; that is, $20 \times 50 = 1{,}000$. See MEASURING-INSTRUMENT.

Mi'cro-nom'e-ter. A species of watch intended for measuring short intervals of time, as the flight of a projectile, etc., has been thus called. After being wound up in the ordinary way it is set in motion by pressing a spring with the finger, upon withdrawing which it is instantaneously stopped.

Mi'cro-pan'to-graph. An instrument invented in 1852 by Mr. Peters, an English banker and microscopist, for minute writing. It consists of an upright stand having four columns *c c* supporting a

Fig. 3133



Peters's Micropantograph.

brass plate *d d*, on which are placed four smaller columns *e e*. On top of these is a second plate *f f* and ring *i i*, in which is journaled an interior ring *j j*; in this is pivoted a lever *g* having its arms in the proportion of 125 to 1. To the shorter arm of the lever is attached an arm *h* carrying the writing-point and sliding-arm *d a*. The lower end of the tubular lever *q* is caused to move in any required direction by means of the rods *s t*, which are connected by two pair of rings *v*, each pair joined together in one plane and each moving on horizontal pivots. The first enters the lower end of the lever *q*, and the second may be moved vertically, and has at its lower end a joint *u* connecting it with the arm *w* which carries the tracing-point; this being moved over the outlines of the letters of a piece of writing or other object, the tracer *d* at the top of the machine produces a reduced copy on a plate of glass fixed beneath it. In the example, this would be reduced to $\frac{1}{125}$ the linear dimensions of the original, or $\frac{1}{15625}$ of its area. This apparatus was improved by the inventor (see right-hand figure), who added an intermediate lever *p* consisting of two parts united by a universal joint; its ends slide in bearings *n n*, *k k* at the ends of the separated parts of the lever *g*, so that the relative lengths of the two parts, which in fact constitute the arms of a compound lever, may be varied within certain limits, so as to vary the proportion between the original and the reduction. The amount of diminution which the instrument is capable of producing may, by thus adjusting the relative length of the levers, be raised between 108 and 6,250 times, lineal measurement.

The writing or engraving point *d* is pressed against the glass plate on which the reduction is made or raised therefrom by springs, a connecting-rod, and a lever operated by the left hand, while the right is occupied with the tracer *x*. See MICROGRAPH; Fig. 3132.

It was stated in 1862 by Mr. Farrants, that the Lord's Prayer, containing 223 letters (*amen* being omitted), had been written on glass with this instrument within the space of $\frac{1}{3560000}$ of a square inch; at which rate the whole Bible might be inscribed within the $\frac{1}{22}$ part of a square inch.

Mi'cro-phone. An instrument for increasing the intensity of low sounds by communicating their vibrations to a more sonorous body which emits a more audible sound.

Mi'cro-scope. An optical instrument by which objects too small to be viewed by the naked eye may be seen and examined.

A *single* or simple microscope is one by which the object is seen directly; it may consist of a single lens or of more than one.

In a *compound* microscope two or more lenses are so arranged that the image formed by one is magnified by the others, and viewed as if it were the object itself.

In a *solar* microscope a reflector and condenser are employed to direct the sun's rays on the object.

In a *lucernal* microscope the rays of a lamp are similarly directed.

The magnifying power of glass balls was known in early times to the Chinese, Japanese, Assyrians, and Egyptians, and more lately among the Greeks and Romans. The use of lenses for microscopes long preceded their application to telescopes. Sir David Brewster exhibited one in 1852 which was made of rock crystal, and was found among the ruins of Nineveh.

The refractive power of glass was known to Ptolemy, who gives a table of the deviation luminous rays experience when passing through glass under different angles of incidence. Descartes discovered the law that the amount of this refraction is proportional to the sine of the angle of incidence, and from that time date all great discoveries in optics.

Glass balls, called burning spheres, were sold in Athens before the Christian era. Their magnifying power was mentioned by the Roman philosopher Seneca, and by Porta of Naples in his "Magia Naturalis," published in 1590.

Alhazen, A. D. 1100, was the first to correct the popular error as to the nature of vision, showing that the rays came from the object and did not issue from the eye, as had been previously supposed. He determined that the retina is the seat of vision, and that impressions made on it by light are conveyed from it along the optic nerve to the brain; he explained that the formation of the visual images on corresponding portions of the two retinas is the cause of our seeing single when we use both eyes; he showed that a ray of light entering the atmosphere obliquely is deflected and follows a curvilinear path, owing to the increasing density of the air as the rays travel towards the earth, and deduced

from the data that the limit of the hight of the atmosphere is about 58½ miles.

Huyghens states that Drebell had a microscope in 1621, and that he was the reputed inventor of it; the invention is also claimed by Fontana, a Neapolitan, in 1618. Burrell asserts that the Janssens, father and son, made the first microscope and presented it to Prince Maurice and Archduke Albert of Austria. The invention was, however, clearly anticipated by Roger Bacon. Spectacles were in use A. D. 1200. The double microscope was invented by Farncelli in 1624.

Dr. Hooke (1635–1702) made microscopes of a sphere of glass, from $\frac{1}{20}$ to $\frac{1}{50}$ of an inch in diameter. Having made and polished his lens, he placed it against a small hole in a thin piece of metal and fixed it with wax.

Leuwenhoeck's microscopes, 26 in number, which he presented to the Royal Society, have each a double-convex lens. Their powers were from 40 to 160.

"Comes Mr. Reeve, with a microscope and a scotoscope. For the first I did give him £5 10 *s.*, a great price, but a most curious bawble it is."—Pepys's *Diary*, 1664.

Stephen Gray's "poor-man's microscope," 1696, was merely a drop of water suspended at the end of a wire or pin. A piece of perforated cardboard or sheet-metal affords a better means of holding the drop of water, whose rounded surfaces give it the properties of a lens.

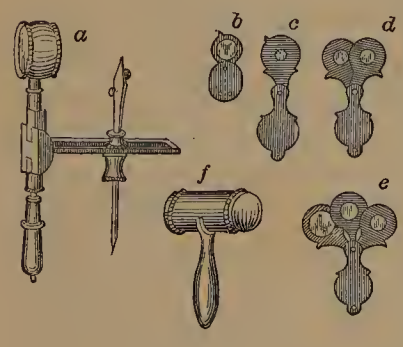
By fusing in the flame of a spirit-lamp a small piece of glass contained within a ring of platinum-wire, a lens may be formed. A piece of the wire should project, so as to form a handle.

Plate-glass is the material commonly used for microscopic lenses. Flint-glass, on account of its great dispersive power, is unsuited for the purpose. Rock-crystal is an excellent material. The diamond and other precious stones have been employed, but the advantage of their high refractive power is found to be counterbalanced by their color, reflective power, double refraction, and heterogeneous structure. The crystalline lenses from the eyes of small fishes give a very perfect image of minute objects.

The lineal magnifying power of a single lens is equal to the distance of distinct vision divided by the focal length of the lens. The object is brought a little within the focal distance of the lens and appears erect.

Fig. 3134, *a* is a jointed microscope for flowers, insects, etc., and is made to fold up and be carried in the pocket. The holder is movable in the slide for focal adjustment and has forceps between which the object is held.

Fig. 3134.



Microscopes.

Simple microscopes, to fold in cases, *b c d e*, are made with one or several lenses, which have a diameter of from ¾ inch to 1¾ inches. They are variously mounted.

The Stanhope lens *f* was invented by Earl Stanhope, and is a cylinder of glass with two convex ends. It is 1½ inches in length and ¼ inch in diameter, and is mounted in a metallic tube. The ends have a relative convexity of 6 to 1, and the instrument has considerable power.

The "Craig" microscope comprises a single lens mounted on a stand, a glass for holding objects below it, and a mirror for reflecting light on the under side of the object and lens. The magnifying power is greater than that of the cheapest compound microscopes, and the instrument simple and convenient to use.

The compound microscope usually has three lenses,—the object-glass, the field-glass, which intercepts the extreme rays passing through the object-glass and thus enlarges the field of view, and the eye-glass. It shows objects in an inverted position. See also Objective.

The United States army microscope, made by Zentmayer, is thus described: It has a brass body, 16 inches high, on brass stand, with joint to incline it to any angle, double-milled head-rack and pinion for coarse adjustment, micrometer-screw for fine adjustment, and movable glass stage; under the stage a tube is fitted for carrying the accessory illuminating apparatus, concave and plane mirrors, arranged for direct or oblique illumination, two eye-pieces, one achromatic object-glass $\frac{8}{10}$ of an inch focus, of 24 degrees angular aperture, one achromatic object-glass $\frac{1}{8}$ of an inch focus, of 80 degrees angular aperture (not adjustable for glass cover), giving power of 50, 100, 250, and 450 diameters: camera lucida, stage micrometer ruled $\frac{1}{100}$ and $\frac{1}{1000}$ of an inch, and a condensing lens two inches diameter on separate stand.

Fig. 3135 represents a microscope especially designed for dentists' use. It has a rack and pinion

Fig. 3135.

Compound Microscope.

for approximate, and a milled headed screw for accurate, adjustment of the focus, and is provided with two objectives having magnifying powers of 125 and 230 diameters respectively. It has also two mirrors, a plane and a concave, a revolvable and removable diaphragm, and a condensing lens on a separate stand.

Daylight or strong artificial light suffices for the observation of an object under a lens or microscope of moderate power, but with high powers more light is required, especially as the object is shaded by the lens. The condenser, a convex lens placed at the side of the object which is in its focus, is then employed. The light may be also concentrated on the object by a reflector.

Lieberkuhn, 1740, devised a hollow concave reflector with a hole in the center, in which was placed a

small lens, the foci of the lens and mirror nearly coinciding. This throws abundance of light on an object placed in the focus, but as it comes equally from all sides no shadows are formed and the object is difficult to define. The device is, however, well adapted for the detection of small particles of metal, etc., in ores.

The Abbé Huc exhibited his microscope to the Regent of Thibet at Lha-Ssa.

"An exceedingly robust specimen of the *pediculus* was kindly furnished by a noble Lama, the secretary to the Regent, from his own preserves. When seized by the nippers, the Lama objected that the experiment would cause the death of a living creature. 'Be silent,' said the Regent. '*Tsong-Kaba!*' cried he, when invited to apply his eye to the glass; 'the creature is as big as a rat.' After looking at it a few moments, he hid his face with his hands, saying it was too horrible to look at. Every one approached the microscope in his turn, and every one started from it with cries of horror. The Lama plead for his little parasite. We removed the pincers and let it fall into the hand of its proprietor. Alas! the poor victim was motionless. The Regent said to his secretary, laughing, 'I think your animal is indisposed. Give it some medicine.'" — *Abbé Huc's Travels in Tartary and Thibet*, 1844–46.

The solar microscope consists essentially of two lenses and a mirror. The mirror reflects the sun's rays upon the first lens, by which they are concentrated on an object placed in its focus, and is still farther magnified by a second lens, which throws the image on a screen at some distance behind it. The exterior lens is placed in a hole through the shutter of a darkened room, and the mirror is adjustable so that it may receive the sun's rays under a proper angle to be reflected to the lenses. The object is here supposed to be transparent; if it is opaque, it must be so illuminated that the rays reflected by it shall pass directly to the interior lens.

The theory of the solar microscope is said to have been invented by Dr. Hooke, and was described by Professor Balthasaurs in Erlange in 1710; but its practical execution is due to Dr. Lieberkuhn in Berlin, who made the first successful apparatus in 1740. It is founded on the same principle as the *camera obscura*, only in place of causing the lens or lenses to form inside of the apparatus a small image of large exterior objects, as is the case with the *camera obscura*, on the contrary, in the solar microscope, the lens or lenses form outside of the apparatus a large image of small objects placed inside the apparatus.

When the objects are opaque and illuminated in front by reflecting mirrors, the apparatus has been called a *megascope*.

The apparatus of the hydro-oxygen and the electric microscope is identical with that of the solar microscope, only that for the solar rays, which are not always at command, the so-called Drummond, lime, hydro-oxygen, or electric light is substituted. The magnesium light has also been used in this way. Either of the above is inferior to the solar microscope in the same ratio that our best artificial lights are inferior to the solar light.

A modification of the above has been adapted for producing enlarged photographs of small objects. The enlarged photograph on glass is then placed in the magic-lantern or stereopticon, and re-enlarged for the benefit of the audience. Or the enlarged view may be taken upon the prepared surface of a wooden block, ready for the skill of the engraver. A beautiful set of engravings, thus produced, were given in Harpers' Magazine some years back.

The mode of obtaining enlarged prints from negatives of ordinary size is explained under SOLAR CAMERA. We are much indebted to Mr. Shive of Philadelphia for the improvements in this apparatus.

The variety of objects which afford interesting subjects for examination by the microscope is infinite. For such, the reader is referred to works treating the subject specially. It is also useful for detecting adulterations in food, drugs, and fabrics, and in many branches of scientific and medical investigation its aid is indispensable. Another use to which it may be applied was disclosed during the late Franco-Prussian war. Copies of newspapers, reduced many-fold in size by photography, were fastened in large numbers to carrier-pigeons and introduced into besieged cities. These were easily read by the microscope.

Microscopic writing has of late years attracted some attention. It is done by means of an instrument composed of a series of connected levers. The operator writes or traces with the longest lever of the system, while the shortest, which carries a marking instrument, faithfully copies whatever may be written. It was calculated that with Peters's machine, at the London Exhibition of 1862, the whole Bible might be copied 22 times in the space of one square inch. It has been proposed to apply this invention to practical use by making private marks, visible only under the microscope, to bills and other papers of value, as a protection against fraudulent imitations; being so minute, a counterfeiter would fail to perceive them, while they would be easily recognized by the proper parties. See MICROGRAPH; MICROPANTOGRAPH.

The prices, as well as the construction, of microscopes vary greatly; those having a magnifying power of less than 200 may be made comparatively simple and at a relatively cheap rate, but when the magnifying power exceeds 300 the whole apparatus becomes more complex, and must be more carefully made in order to handle, focus, and illuminate the objects properly, center the lens correctly, etc. In these the stand alone costs nearly $100, the eye-glasses $5 to $10 each, and the object-glass on Selligne's system from $10 to $75 each, according to power.

Besides eye-pieces and objectives of different powers, there are a number of necessary or useful appendages, as, condensing lens, prismatic illuminator, dark well, parabolic reflector, lieberknhn, polarizing prism, micrometer, camera for delineating objects, etc., which tend to augment the price, so that a complete compound microscope costs from $300 to $1,000. The binocular microscope is, of course, still more expensive, the price in some instances reaching $15,000. A good instrument, however, amply sufficing for the wants of ordinary amateur observers, may be obtained for $100.

See "Carpenter on the Microscope"; Hogg's "History of the Microscope," etc.

The investigations of Leuwenhoeck, Schwammerdam, and the earlier microscopic inquirers, were conducted by means of single lenses, the compound microscope being esteemed comparatively untrustworthy, its true theory being imperfectly understood.

In 1829, Mr. J. J. Lister published the results of his investigations into the laws governing the aberrations of lenses, and gave practical directions for correcting them by combinations of lenses so arranged that the aberrations should balance each; from this period date the great and rapid improvements which have since been made in the compound microscope.

Among recent important improvements in the microscope is the illuminator of Professor Hamilton L. Smith, for opaque objects, in which the light is

received upon a mirror behind the object-glass, through which it is reflected upon the object. Also his mechanical finger, by which objects invisible to the naked eye are picked up on the point of a hair, separated according to kind, and arranged conveniently for observation.

After the discovery of the theory of binocular vision by Wheatstone in 1838, and especially after the construction of the lenticular stereoscope by Sir David Brewster in 1852, the idea naturally occurred of applying this principle to microscopes. This was first effected by Professor J. L. Riddell of the University of Louisiana. He employed a pair of small rectangular prisms immediately behind the object-glass ; these received the incident rays and reflected them through a second pair of similar prisms to the eye of the observer. This arrangement had the disadvantage of reversing the stereoscopic effect, projections appearing as depressions, and *vice versa*.

The first arrangement for producing a correct stereoscopic effect was invented by Mr. Nachet, and consisted of an equilateral prism which divided the pencil of rays into two equal parts, reflecting them to two similar prisms, right and left hand, which reflected them to the eye of the observer.

The Wenham binocular (Fig. 687, p. 285), in which the compound pencil is divided by means of a trapezoidal prism, has, however, on account of its greater simplicity of construction, been more generally employed.

Mr. Nachet has since introduced a simpler form of binocular microscope, which may be applied to an ordinary instrument without altering its construction or impairing its usefulness as a monocular. This is effected by making an opening in the side of the tube, into which is introduced a rectangular prism which reflects half the pencil of rays horizontally ; this is received on another prism, which directs it to the eye of the observer. Arrangements are made for varying the distance between the tubes to accommodate them to the varying distances between the eyes of different persons.

The disadvantage common to binocular microscopes on this plan is that they perform well only with comparatively low magnifying powers. This led to the suggestion a few years ago by Mr. Wenham of a method of dividing the pencil by means of a transparent plane reflector, which, adjusted at a proper angle, might reflect one half the light of each pencil, allowing the other half to pass through. This plan involves the loss of the stereoscopic effect, but secures to the observer the satisfaction of using both eyes in viewing an object. It has, however, proved somewhat difficult to carry out this idea satisfactorily in practice. See PRISM.

Messrs. Powell and Lealand of London have patented an arrangement, consisting of a quadrangular prism which receives the rays, part of which pass through, while the remainder are reflected to a triangular prism which transmits them to the eye. This has the disadvantage of causing the object to appear unequally illuminated in the two tubes.

Mr. R. B. Tolles has constructed an instrument designed to remedy the defects of the original binocular microscope, at the same time permitting the ordinary single-tubed instrument to be used as a binocular. The double eye-piece has prisms similar to those employed in Nachet's earliest form, placed at a distance from the objective about equal to that of ordinary eye-pieces. In this form it is necessary that the axes of the pencils of rays should cross each other a second time, and for this purpose an erecting eye-piece is employed.

Professor H. L. Smith has proposed a form of binocular, consisting of a thin plane reflector, inclined at an angle of 80° to the axis of the telescope ; a ray of light from the object, striking the surface of the mirror, is in part transmitted without change of direction, and in part reflected to a triangular prism having one of its angles truncated, where it undergoes a second reflection to correct the reversal produced by the first, and is transmitted along the axis of the secondary tube. By this arrangement, the intensities of the light of the directly viewed and reflected images appear sensibly equal.

It is obvious that, after the division of the beam of light from the object, it is merely a matter of detail to give each of the divisions a direction proper to be viewed by two or more observers. This affords great advantages, not only in anatomical and other investigations, but, where the instrument is used merely for curiosity, it enables several persons to observe at the same time, thus greatly economizing time.

In the triple microscope for three observers, the beam of light is divided into three equal parts by a combination of suitable prisms, each part being directed into its proper tube. Provision is made for the general adjustment of the lenses, and also for the adjustment of the eye-piece of each tube to the eye of the particular observer.

The construction of the *stand* is a matter of considerable importance, as upon its arrangement largely depends the degree of illumination and the distinctness with which the objects can be viewed. A good arrangement of this kind, constructed by Tolles, comprises a movable stage having two tables, one facing upward and the other downward, firmly connected together and controlled by milled heads. When the object is placed on the lower table, it is secured by spring clips. In this case, the central part of the upper table is removed, and the objective descends through the opening. Any degree of obliquity of illumination, even up to 90°, is thus available for viewing the object. The stage is also capable of rotation on its optical center throughout the entire circle.

Mi'cro-spec'tro-scope. A spectroscope placed in connection with a microscope, in order that the

Fig. 3136.

Higgins's Microspectroscope.

absorption lines may be the more accurately measured. The eye-piece contains prisms so placed as to enable the reflected ray to pass in a direct line to the eye. *a* is the first lens of the eye-piece ; *b* the screw for adjusting the slit which reduces the beam to a line of light ; *c* is the second lens, where the rays

are rendered parallel, after which they pass through three crown-glass prisms *m*, placed in one direction, and two flint-glass prisms, placed in the other direction, so that the spectrum is seen by looking straight at the source of light, the instrument being a direct-vision spectroscope.

The instrument is notably employed in viewing the absorption bands of blood in toxicological research. By means of the mirror *d*, a ray of light, shown by the dotted line, may be sent through a slit at one side of the instrument, which, being reflected upward, passes through the prisms along with the other light which came from the object under the microscope, and by this means the two spectra may be compared, one object being a liquid supposed to be blood, and the other one known to be blood, and so on.

Mi'cro-tome. A knife for making thin sections for microscopic examination. A pair of parallel knives in a single haft. See PARALLEL KNIFE.

Mid'dle-cut File. A file whose teeth have a grade of coarseness between the *rough* and *bastard*. See FILE.

Mid'dle-post. (*Carpentry.*) A king-post in a TRUSS (which see).

Mid'dle-press'ure En'gine. (*Steam-engine.*) An English term applied by some to a low-pressure or condensing engine, adapted for working at a pressure of steam comparatively high for its class, say 25 pounds or upward to the square inch.

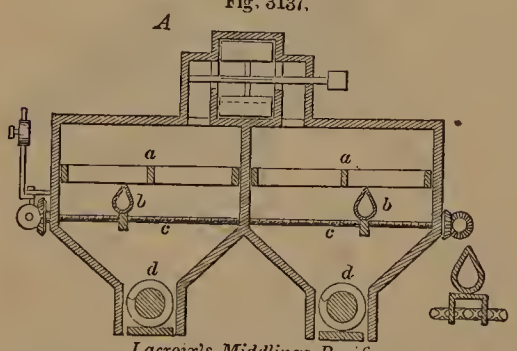
Mid'dle-shot Wheel. (*Hydraulic Engine.*) A *breast-wheel* which receives the water at about its middle hight.

Mid'dling. That portion of a gun-stock between the grasp and the *tail-pipe* or ramrod-thimble.

Mid'dlings-pu'ri-fi'er. (*Milling.*) An apparatus for cleansing the intermediate product of ground wheat termed *middlings*, and separating it from bran on the one hand and fine flour on the other. This was originally effected exclusively by passing the flour delivered from the millstones successively through a series of cylindrical bolts covered with cloth of different degrees of fineness, which were set in rapid rotation and brought in contact with a series of longitudinal rods termed beaters, the bolts separating in succession the finer and coarser qualities of flour and the middlings, the bran being retained within the last cylinder. See FLOUR-BOLT; BRAN-DUSTER.

This was succeeded by the dressing-machine, in which a like cylinder, rotating on an inclined axis, is covered with wire-gauze of several degrees of fineness, the coarsest being placed at the lower end; the flour is thus graded during its passage from the

Fig. 3137.



Lacroix's Middlings-Purifier.

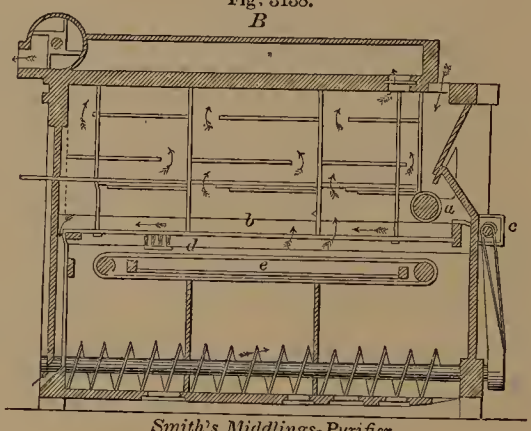
upper to the lower part of the cylinder, the middlings passing through the comparatively coarse meshes of the lower cloth while the bran passes out at the end as tailings. The interior of the cylinder is provided with a revolving reel set with brushes, which force the meal through the meshes of the cloth. When clogged, the cylinder is cleaned by an interior brush operated by the machinery.

As at present constructed, machines of this kind may be divided into five classes, an example of each of which is given.

A (Fig. 3137) is one in which air, forced through perforated pipes, is used for cooling the flour and clearing the meshes of the cloth. The middlings are fed through hoppers over the screens *a a*, and are purified by a current of air passing through the tubes *b b*, which are arranged on the screw-threaded shaft *c c*, alternately rotated in opposite directions, causing the tubes to traverse from side to side of the screens; the lighter matters are drawn upward and carried off by a fan, while the middlings, passing through the screen, are removed by the screw-conveyors *d d*.

Fig. 3138, *B*, is a purifier in which brushes are employed for clearing the meshes of the cloth. The meal or middlings is fed by rollers *a* to the bolt *b*,

Fig. 3138.

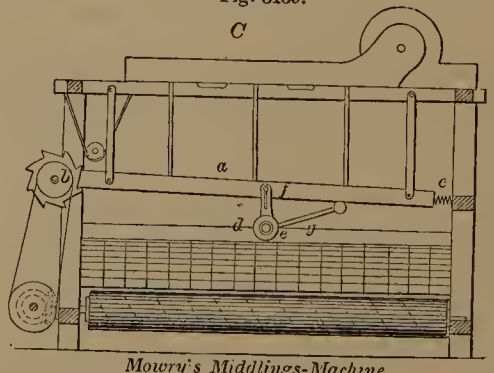


Smith's Middlings-Purifier.

its amount being regulated by a slide; a shaking motion is imparted to the bolt by an eccentric *c* on a shaft, and a continuous upward current of air is passed through the machine; fine particles adhering to the bolting-cloth are removed by brushes *d* attached to endless belts *c*.

Fig. 3139, *C*, shows a machine with reciprocating shakers, with knockers for clearing the meshes of

Fig. 3139.



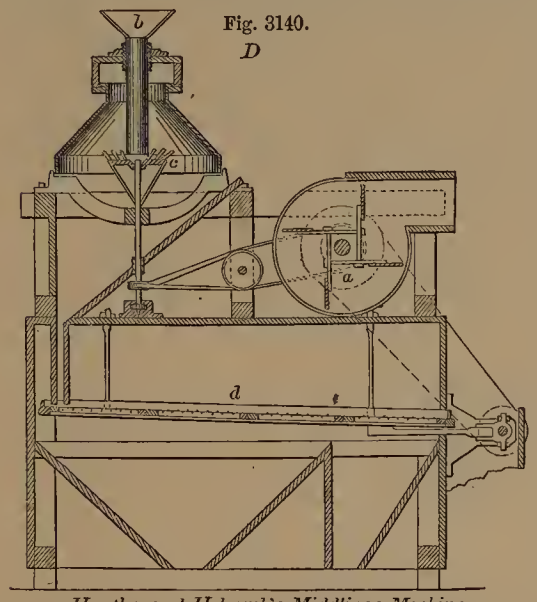
Mowry's Middlings-Machine.

the cloth. In this machine the suspended shaker *a* is pressed against the ratchet-wheel *b* by a spring *c*, the rotation of the wheel causing a vibration of the shaker; *d* is a rock-shaft, pivoted at *c*, loosely connected with the shaker by a slot and pin at *f*, and

provided with an arm *g* carrying a hammer, which strikes the bottom of the shaker at each reciprocation.

Fig. 3140, *D*, shows whippers or beaters in connection with an air-blast for operating on the mid-

Fig. 3140.
D

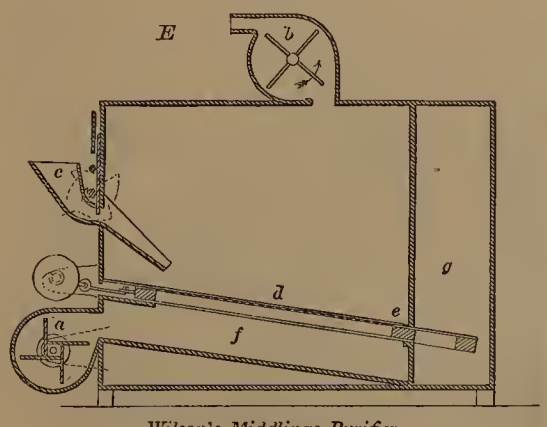


Huntley and Holcomb's Middlings-Machine.

dlings before bolting. A fan *a* produces an air-blast which is carried upward through an inclined trunk ; middlings from the hopper *b* are caught by a revolving cone or disk *c*, provided with upwardly projecting pins, disengaging particles of dirt which adhere to the coarser particles of the meal ; these are carried off by the blast, while the valuable portions slide down an incline to the sieves *d*, which are vibrated in the usual manner by a cam-shaft ; the coarser and harder portions of the meal fall through the sieves, while foreign matters are finally shaken out at their ends and delivered into a spout.

E (Fig. 3141) uses both suction and an air-blast. In this machine a blower *a* and exhaust-fan *b* are employed ; the stuff from the hopper *c* is fed inter-

Fig. 3141.



Wilson's Middlings-Purifier.

mittingly to the screen *d* by means of a cut-off plate, while the screen has a longitudinal motion, and is divided into two parts by a partition *e*, one part being immediately over the air-tight chamber *f*, while the other projects within the air-tight chamber *g* ; the first part is provided with cloth of such fineness that none of the middlings can pass, but the other allows the granulated portions to pass to a spout, by which they are conveyed to a receiver ; the tailings fall over the lower end of the screen into another receiver.

The fine particles of dust and dirt are driven upward by the blower *a* and carried away by the exhaust-fan *b*. See "Digest of Middlings-Purifiers," DeW. C. Allen, Washington, 1873.

Mid-feath'er. (*Steam.*) A water-bridge in a steam-boiler furnace which occupies a middle position in the flue-space, the flame passing both above and below it.

Mid'ship-beam. (*Shipbuilding.*) The longest beam in the middle of a ship.

Mid'ship-bend. (*Shipbuilding.*) The *midship-section* or the largest of the cross-sections of a ship. When the middle of the ship has a portion of a uniform cross-section, such is called the *midship-body.*

Mid'ship-frame. The frame at the midship or largest section of a vessel.

Mil'i-ta-ry-bridge. A bridge, usually of a temporary character, designed for the passage of an army with its artillery and supplies or for maintaining its communications.

Probably the earliest on record is that thrown by Darius across the Bosphorus during his invasion of Greece, 490 B. C.

Ten years later, his successor, Xerxes, crossed his army, said to have been 1,700,000 strong, from Asia into Europe by similar means.

The bridge of Xerxes across the Hellespont consisted of ropes resting on galleys and supporting planks. The account given by Herodotus may be thus briefed : —

Two parallel bridges were constructed, one supported by 360 vessels and the other by 314. The vessels are classed as *triremes* and *penteconters*, and were anchored parallel, the prows facing up stream, that is, toward the Euxine. To each bridge were assigned six cables, "two of white flax and four of papyrus." These were stretched across the strait, lying upon the vessels, and drawn taut by wooden capstans on the Abydos and Chersonese shores. One bridge was for the army, and the other for the sumpter animals. "Trunks of trees were sawn into planks, which were cut of a length to suit the width of the bridge, and these were laid side by side upon the tightened cables and then fastened on the top. This done, brushwood was brought and arranged upon the planks, after which earth was heaped upon the brushwood and trodden down solid. Lastly, a bulwark was set up on each side of this causeway of such a hight as to prevent the sumpter beasts and the horses from seeing over it and taking fright at the water." — Herodotus, VII. 36.

The army was seven days and nights in crossing.

The bridge thrown across the Rhine by Cæsar, for the purpose of enabling him to cross that river in order to chastise the Germans, who, under their king, Arioristus, had invaded the Gallic territory, was formed by driving piles 18 inches square into the bed of the river, in pairs 2 feet apart and slightly inclined. Opposite these, at a distance of 40 feet, was another pair of piles, inclined in the opposite direction. These were connected by beams 2 feet in diameter, on top of which were laid joists running in the direction of the breadth of the river, and covered with hurdles to form a roadway.

On the side below the bridge inclined piles were driven, serving as braces against the force of the current ; and on the upper side were others to ward off floating objects, as trees or boats. The whole was completed and the army passed over in ten days. See Bridge.

Trajan's bridge over the Danube, erected 150 A. D., for the purpose of keeping in check the warlike Dacians, was one of the most remarkable structures of antiquity. It was built on stone piers supporting wooden arches, on which the superstructure rested. It was destroyed by his successor, Hadrian, who thought the Roman Empire was already large enough, and wanted no provinces beyond the Danube. The remains of the piers are existing at the present day. See BRIDGE.

Military bridges, of a temporary character, are made with piles, trestles, boats, pontons, or casks.

Pile-bridges are applicable in shallow rivers with deep mud, and where boats are not accessible or the stream not navigable.

Trestle-bridges are applicable under similar circumstances, where the material at hand suits better that mode of construction.

Boat-bridges are made by fastening them alongside each other to a cable moored on each bank of the stream. Over the boats are laid the *balks*, and crossing these the *chesses* or flooring-boards.

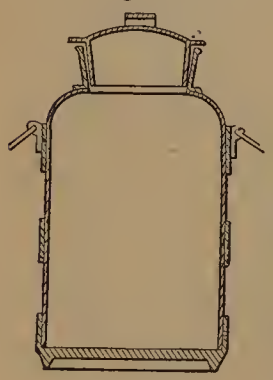
Ponton-bridges are laid upon *bateaux* or *pontons* carried by the army, and forming the *ponton-train*. They are laid like the boat-bridge or anchored.

Casks lashed to spars have been used as *pontons*. See PONTON-BRIDGE; TRESTLE-BRIDGE.

That end of the bridge toward the enemy is protected by a fortification (a *tête de pont*), a redan, or redoubt, according to the nature of the ground, and when practicable, by batteries arranged to command its approaches.

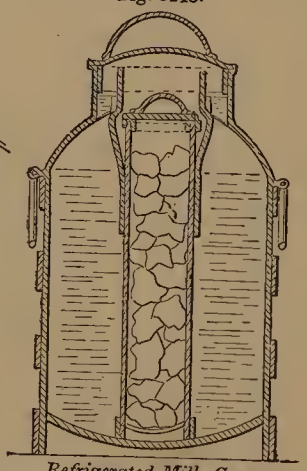
Milk-can. One adapted to the jars and blows incident to the conveyance of milk to market and to customers. In the example, the sheet-metal portion has strengthening bands, and is riveted to a cast-iron bottom, on which it may be rolled without bruising.

Fig. 3142.



Milk-Can.

Fig. 3143.



Refrigerated Milk-Can.

Fig. 3143 shows a can with an interior removable ice-chamber. This has a closely fitting stopper, secured in the can by a flange at the bottom, an annular band at the top, and springs to keep it in place. The inner vessel is filled with ice to keep the milk cool.

Milk, Con-densed'. Recipes for preserving milk:—

1. Add sugar; evaporate to one fourth; solder in cans.

2. Add carbonate of soda and white sugar; evaporate to dryness; cut into cakes.

3. Add sugar and alkali; evaporate to dryness; crush, powder, and bottle.

4. Evaporate to one half; beat up with white of egg; simmer, skim, strain, and boil.

English recipe, 1856. Fresh skimmed milk, 1 gallon; sesquicarbonate soda, 1½ drams; mix, evaporate to ⅓ by steam-bath, accompanied by agitation; add powdered white sugar, 3½ pounds; complete the evaporation and reduce the mass to powder; add the cream, incorporate, and seal hermetically.

Old recipe. Carbonate soda, ½ dram; water, 1 fluid ounce; dissolve; add fresh milk, 1 quart, sugar, 1 pound; reduce to a sirup in a steam-bath, and finish the evaporation on plates in an oven.

At the works of the Aylesbury Condensed Milk Company in England 200 persons are employed, and the milk of 1,200 cows, each yielding 14 quarts, is daily evaporated. The milk is brought in tin cans by the surrounding farmers, is tested by taste, smell, and the lactometer, partially evaporated in a vacuum-pan, mixed with sugar, and finally condensed until its original proportion of water, 87 per cent, is reduced to 25 per cent. The condensed liquid has a semi-fluid consistence, and the "Lancet" gives the following analysis:—

Water	25.10
Butter	11.73
Caseine	15.17
Milk-sugar	16.24
Cane-sugar	29.46
Ash	2.30
	100.00

Borden's (American) process of condensing milk is protected by letters-patent. There are a number of factories for preparation of condensed milk in and about New York, where it is sold from house to house fresh from the condensing-vats. Thousands of gallons of milk are daily prepared to supply the demand in the army and navy, and for foreign consumption.

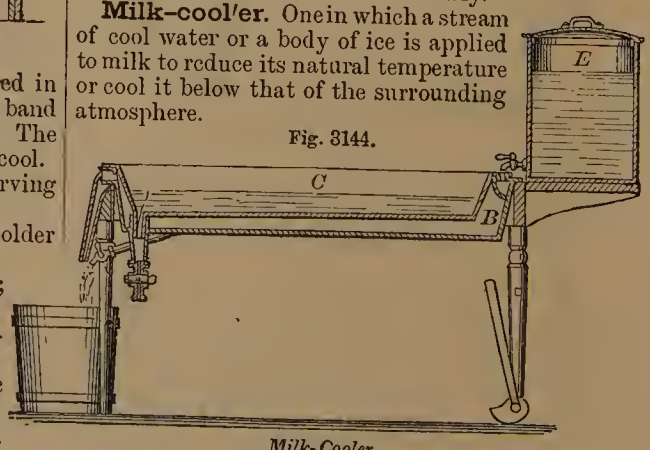
The usual process of evaporation is to place the milk in large shallow pans, each having a pump to exhaust the air. The water is driven off by a steam-heat of about 160 degrees. When the desired condensation is attained, sugar is added if the product is to be preserved beyond a few days, and other chemical agents according to the process.

Pure milk condensed to one third will remain sweet from 5 to 10 days in warm weather.

In Kirchofer's process the milk is not condensed, but as fresh drawn from the cow, is placed in cans or bottles, which are filled as nearly full as possible, immediately hermetically closed, and placed in a bath of water whose temperature is then slowly raised to between 160° and 170° Fah., and kept at this temperature for a greater or less length of time, according to the period during which it is desired to preserve the milk. The fire is then withdrawn and the bath allowed to cool down slowly.

Milk-cool'er. One in which a stream of cool water or a body of ice is applied to milk to reduce its natural temperature or cool it below that of the surrounding atmosphere.

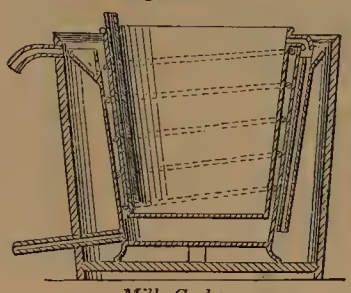
Fig. 3144.



Milk-Cooler.

In Fig. 3144, the water from a reservoir *E* passes through the pan *B* beneath the milk-pan *C*, and is discharged into the bucket.

Fig. 3145.



Milk-Cooler.

In Fig. 3145, the milk flows down a spiral track between the two metallic vessels, is cooled in its passage by the contents of the outer and inner vessels, and is discharged.

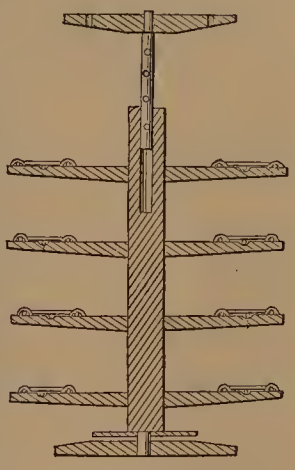
Milk'er. Cow-milkers are of two kinds : one of them depends upon a cannula, which penetrates the lacteal orifice beyond the region of the sphincter muscles, which close the opening and prevent the involuntary emission of the milk ; the other depends upon mere pneumatic pressure, the teat being inclosed in a cup whose lower end is connected by a pipe with an air-exhausting apparatus and a vessel to receive the milk.

Colvin's hydraulic cow-milker combines a cattle-stall and compound milking apparatus, operated by power. Several machines are ranged in a row, one to each stall, and are designed to be operated by one attendant. The power runs continuously, and the man allows a cow to pass through and admits another, which is secured in place, and the apparatus attached. The milk runs into large cans partially sunk in the floor. It is said that three machines are sufficient to milk sixty cows in the time it would take six men to milk them by hand.

The milkers are worked by pumps, the pistons of which are driven by power. They are attached by a jointed iron pipe to allow of the movement of the cow forward, backward, or sideways, always adapting itself to her motions. The teat-cups are of corrugated rubber, closely enveloping the teats of the cow. The pumps oscillate, giving the natural motion of the calf in sucking, or of the hand in milking ; the space between the elastic diaphragm in the milker and the pump is filled with water, which, in working the pumps, oscillates in the tube and produces a vacuum at each alternate stroke of the piston.

Milk-glass. A kind of glass having a semi-translucent or milky appearance, and known by the names of CRYOLITE-GLASS or FUSIBLE PORCELAIN (which see).

Fig. 3147.



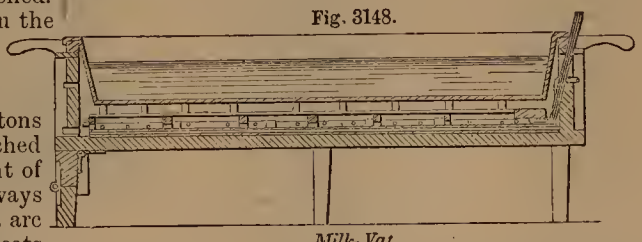
Milk-Rack.

Milk'ing-shield. A protecting plate over the breast, having a perforated cap over the sore nipple, to protect the same against actual pressure by the mouth of the infant when nursing. See NIPPLE-SHIELD.

Milk-rack. A series of shelves in a dairy to hold milk-pans. That shown is rotatable on its axis.

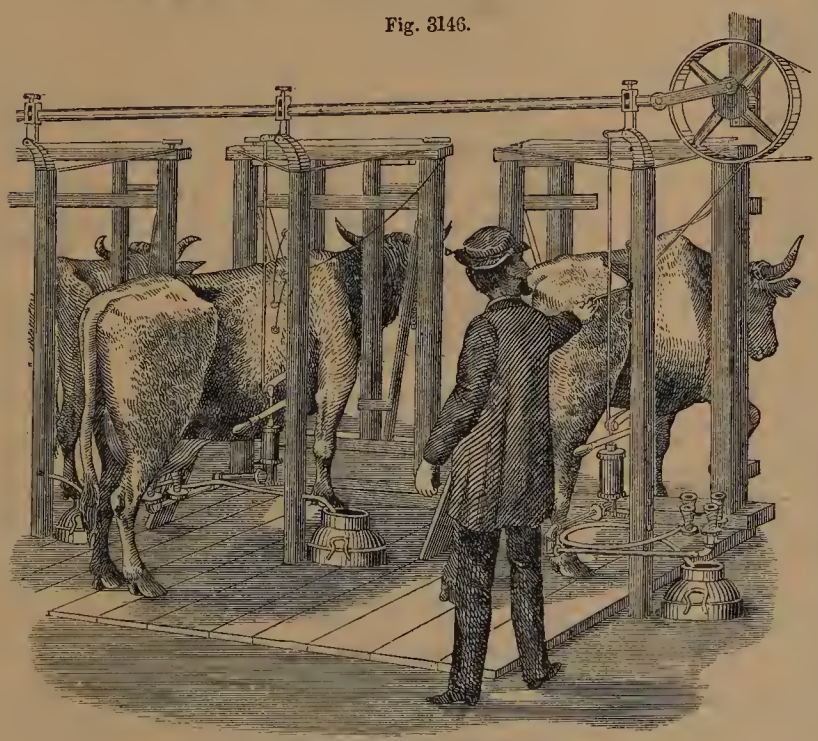
Milk-vat. A deep pan for setting milk to raise cream or curdle for cheese. In the example, steam and water pipes are introduced between the exterior and the interior vats to regulate the temperature of the contents of the latter.

Fig. 3148.



Milk-Vat.

Fig. 3146.



Colvin's Patent Hydraulic Cow-Milker.

Mill. 1. A machine for grinding.

2. A lapidary's grinding-wheel, known as a roughing-mill, cloth-mill, etc.

3. To serrate or dent the edges of coin.

4. To *throw* undyed silk.

5. A building or factory containing machinery.

6. (*Die-sinking.*) The hardened steel roller having the design in *cameo*, and used for impressing in *intaglio* a plate, — as in the bank-note system of engraving ; or a copper cylinder, — as in the process of engraving cylinders for calico-printing.

The design is engraved on a small steel plate or roller, which is subsequently hardened by heating it to a cherry-red in an iron case containing pounded bone-ash, and then plunging it into cold water, its surface being protected from oxidation by a chalky paste. This hardened roller is called the

die. The *die* is then placed in a transferring-press, where, by rotatory pressure, it is made to impress its design upon the surface of a softened steel roller placed in apposition to the said *die*. The soft roller has the design in *cameo*, is hardened, and forms a *mill*, which is capable of delivering an *intaglio* impression upon a plate or roller, as above stated. The process was invented by Jacob Perkins, and adapted to engraving cylinders for calico-printing by Locket of Manchester, England.

See under the following heads : —

Amalgamator.
Arrastra.
Bait-mill.
Bark-mill.
Barker's mill.
Barley-mill.
Battery.
Bean-mill.
Bone-mill.
Boring-mill.
Camp-mill.
Cane-mill.
Caoutchouc-mill.
Cement-mill.
Chilian mill.
Chocolate-mill.
Cider-mill.
Clay-mill.
Coal-breaker.
Cocoa-mill.
Coffee-huller.
Coffee-mill.
Corn-sheller.
Corn-mill.
Croze-mill.
Crushing-mill.
Current-mill.
Cylinder-mill.
Decorticator.
Devil.
Diamond-mortar.
Disintegrator.
Drug-mill.
Edge-mill.
Flatting-mill.
Flint-mill.
Fulling-mill.
Gig-mill.
Grain-bruiser.
Grain-huller.
Grinding-mill (varieties, see GRINDING-MILL).
Grist-mill.
Gunpowder-mill.
Hand-mill.
Hominy-mill.
Horizontal mill.
Huller.
Indigo-mill.
Kibbing-mill.
Lead-mill.
Linseed-mill.
Malaxator.
Masticator.
Mill-wheel.
Molding-mill.
Mortar.
Mortar-mill.
Muller.
Oil-cake mill.
Oil-mill.
Ore-mill.
Paint-mill.
Pearl-barley machine.
Pearling-mill.
Peat-machine.
Percussion-grinder.
Pestle.
Plaster-mill.
Polishing-machine.
Polishing-mill.
Porcelain-mill.
Porphyrization.
Post-mill.
Powder-mill.
Pug-mill.
Pulp-mill.
Quartz-mill.
Quern.
Rasping-mill.
Revolving-pan mill.
Rice-huller.
Rice-mill.
Rock-pulverizer.
Roller-mill.
Roughing-mill.
Runner-ball.
Sand-crusher.
Sand-pulverizer.
Saw-mill.
Sheller.
Shingle-mill.
Shingling-mill.
Slitting-mill.
Smock-mill.
Smoothing-mill.
Smut-mill.
Snuff-mill.
Sorghum-mill.
Spice-mill.
Spinning-mill.
Stamp-mill.
Stamping-mill.
Steel-mill.
Stone-mill.
Sugar-mill.
Sugar-cane mill.
Throwing-mill.
Tide-mill.
Tread-mill.
Turning-mill.
Veneer-mill.
Warping-mill.
Water-mill.
Wheat-huller.
White-lead mill.
Windmill.

Mill-bar. The rough bar, as drawn out by the puddler's rolls. As distinguished from *merchant-bar*.

Mill'board. A stout pasteboard made of strong materials, such as refuse flax, cotton, and hemp, rope, or bagging ; and used for the stiff portion of book-covers, and for other purposes. It is also used for packing between the flanges of pipes, being previously soaked in oil.

A commoner article is made of other coarse fiber, such as jute (cochorus), asclepias, sorghum, bark, straw, bamboo, grass, gama grass, New Zealand flax, and other materials.

Mill'board-cut'ter. A machine for cutting heavy board, for book-covers and pasteboard boxes.

Fig. 3149 shows a machine of this class. The sheets of pasteboard are fed between two shafts which carry disks or knives capable of adjustment at proper distances apart. The board is thus cut into strips, which are divided into parallelograms by a second feeding through the machine.

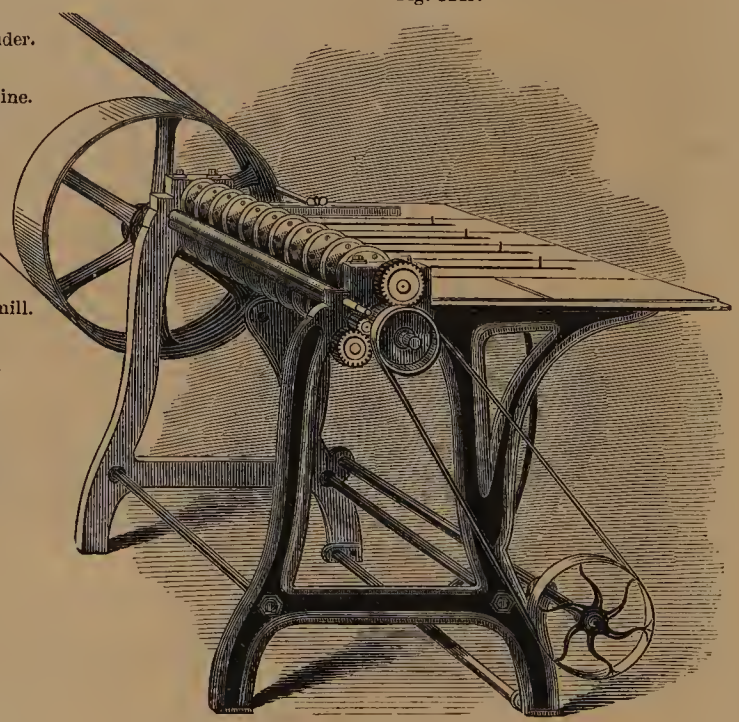
Mill-cake. 1. The incorporated materials for gunpowder ; in the cake form, previous to granulating.

2. The mass of hulls and parenchyma remaining after the expression of linseed-oil.

Mill-dam. A wall or bank across the course of a stream to raise the level of the water and divert it into a mill-race. See DAM.

Milled Lead. Lead which has been spread into

Fig. 3149.



Chambers's Automatic-Feeding Board-Cutter.

a sheet in the *rolling-mill*, in contradistinction to lead which is leveled while in a melted condition, upon a table with raised edges by means of a *strike* in the hands of two men.

Milled Cloth. (*Fabric.*) Woolen cloth which has been fulled or felted by beating, to thicken it.

Double-milled ; the operation having been repeated to increase the density.

Mil'le-fi-o're-glass. A number of pieces of filigree, or tubes of glass enamel, are fused together, their sections representing stars, flowers, and other ornaments.

Sections of these tubes are imbedded in white transparent flint-glass, forming paper-weights.

It is a species of *mosaic* enveloped in a transparent bulb.

Mill-fur'nace. (*Metal.*) A reheating furnace. A furnace where the puddled metal is reheated, preparatory to again passing through the rolls.

Mill-gang. In warping ; that part of the warp which is made by a descending and ascending course of the threads round the warping-mill.

Mill-hop'per A-larm'. An attachment to grinding-mills to indicate that the grist has about run out of the hopper. Mills have been burnt by the heat and sparks generated by the stones when running empty, and several devices have been patented

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